SPECIAL ISSUE
ON MANAGING RADICAL CHANGE

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The primary goal of the Acquisition Review Quarterly (ARQ) is to provide practicingacquisition professionals with revelant management tools and information based on recent advances in policy, management theory, and research. The ARQ addresses the needs of professionals across the full spectrum of defense acquisition, and is intended to serve as a mechanism for fostering and disseniating scholarly research on acquisition issues, for exchanging opinions, for communicating policy decisions, and for maintaining a high level of awareness regarding acquisition management philosophies.

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TABLE OF CONTENTS

Dear Readers,

My sincere appreciation goes to the Naval Postgraduate School—the Guest Executive Editor for this Special Issue of the *Acquisition Review Quarterly* journal—and the authors and reviewers that made this issue possible. The theme MANAGING RADICAL CHANGE is the right topic at the right time and in the right publication.

The more the Defense Acquisition Workforce learns about change management, the better we can provide the warfighter and taxpayers with systems that are produced better, faster, and cheaper. I believe that the articles by the Naval Postgraduate School in this Special Issue provide invaluable information and advice for doing so.

Another publication that may interest our ARQ readers is the 1996–1997 DSMC Military Research Fellows Report *A Model for Leading Change: Making Acquisition Reform Work*, available from the DSMC Publications Distribution Center at (703) 805-3726, and the Government Printing Office at (202) 512-1800.

We welcome your suggestions on future theme issues. We are always eager to receive quality articles for our review and consideration. And we are always looking for subject-matter experts to participate in our blind referee process.

Please visit the DSMC Home Page (http://www.dsmc.dsm.mil) for back issues of DAU's *ARQ* journal and DSMC's *Program Manager* magazine, and other online versions of our publications.

Yours truly,

Dr. James E. Price
Executive Editor,
Acquisition Review Quarterly

MANAGING RADICAL CHANGE IN ACQUISITION

Dr. Mark E. Nissen, Dr. Keith F. Snider, and Dr. David V. Lamm

The acquisition process is critical to the survival of commercial and defense enterprises alike. Despite this critical role, however, the acquisition process is far from being healthy and robust. Notwithstanding considerable progress through legislation, acquisition reform and some process innovation, acquisition continues to plague the Defense System and constrain battlefield mobility, information, and speed. Following the lead of industry—in which many progressive firms have radically changed their acquisition process and elevated acquisition to a strategic level of importance—and Secretary Cohen's call for new approaches to leading change in a new era—radical change of unprecedented scope, pace, and importance is now required for the DoD, change that requires a quantum increase in new acquisition knowledge.

The purpose of this Special Issue is to catalyze the quality and quantity of new acquisition knowledge produced through scholarly research. In preparing for the articles published in this issue, we targeted scholars in universities and other research institutions, both within and outside the federal government, to engage their interest in defense acquisition as a primary area of research. These researchers represent a tremendous potential resource for realizing improvements in acquisition and can effect considerable leverage in terms of high-quality research through minimal direct funding. And unlike much past acquisition research, we have insisted on the same, high-quality standards maintained by the best scholarly journals, in which top researchers from leading universities normally publish their work. This approach leads to a program for producing new acquisition knowledge that is efficient as well as effective—important considerations in these times of lean Defense budgets. Although it is only a modest beginning, we have endeavored to augment the Secretary's Defense Reform Initiative—and noteworthy forward steps by the Defense Acquisition University, *Acquisition Review Quarterly*, and Naval Postgraduate School—by catalyzing renewed, increased interest in top-quality acquisition research. The seven following articles contained within the Special Issue represent the fruits of this initial effort to catalyze the prolific and systematic creation of new acquisition knowledge.

The acquisition process is critical to the survival of commercial and defense enterprises alike. The process transforms user needs into products, services, and information that are required to satisfy those needs. In its current usage, the term *acquisition* pertains to the strategy, planning, procurement, contracting, program management, logistics, and other activities that are required to develop, produce, and support systems and other materiel to accomplish the mission of an enterprise. Although acquisition is generally described in the context of weapon systems development (i.e., in support of the defense mission), the breadth of this term indicates that it does not apply solely to the Department of Defense (DoD); rather, most enterprises in the public and private sectors alike engage in acquisition.

Despite this critical role, however, attention to the acquisition process is lacking. In DoD as well as in industry, acquisition has long been relegated to the "end of the line" in terms of executive attention, funding, innovation, training, advancement, and other key enterprise attributes. In the DoD for example, we have long heard funding and prioritization arguments based on the "tooth versus tail" metaphor. That is, if an organization is financially constrained and unable to procure sufficient assets to support all its needs and desires, then priority is given to combatants and weapons (i.e., the teeth) over procurement, program management, and even logistics. This appears to be rational because, clearly, contract administrators do not march into battle. Corporate America has long relied on this same argument as well. In the past, few corpo-

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rations would hesitate to shift discretionary spending from quality assurance to manufacturing, from customer service to marketing, from purchasing to research and development (R&D) and like prioritizations.

Now, progressive firms are shifting their emphasis and priorities. Industry discovered in the 1980s that quality represents a critical performance factor, for example, as customers increasingly demand quality products. Firms also discovered that customers increasingly demand courteous and responsive service, and that the most brilliant marketing campaign in the world is ineffective at winning back a customer who has been lost to poor service. Most important, the key message from Total Quality Management is that emphasizing quality can actually save cost and reduce cycle time. The need for change is particularly evident in R&D, the fundamental mechanism for new product and service development for the hierarchy (see Williamson, 1985 for a comparison of markets and hierarchies). The often lengthy time from basic research to new product introduction can limit a firm's agility, flexibility, and responsiveness to unforeseen changes in the environment and competitive arena (Porter, 1985). Thus, we now observe strategic networks among organizations, decreased process cost and cycle time, increased flexibility and agility, and a host of other signals that radical change has indeed occurred.

Widespread supply-chain integration, just-in-time inventory practices, virtual organizations (Davidow and Malone, 1992), electronic markets (Malone et al., 1987), mass customization (Pine et al., 1993) and other contemporary business practices have required a radical change in the acquisition processes of progressive firms. For example, the procurement focus has shifted away from short-term transactions and more toward strategic relationships. Although price is still vitally important (as always), it is no longer necessarily more so than capability, quality, reliability, and trustworthiness. In many cases, the relationship established with a particular vendor, customer, distribution channel, or even a competitor makes the difference between being first to market with an innovation or missing the product cycle completely—perhaps while haggling over five percent of a current transaction's purchase price. In today's era of hypercompetition (D'Aveni, 1994), global operations, and exploding information, progressive companies realize that the environment has shifted abruptly and are effecting radical change where called for.

"Most important, the key message from Total Quality Management is that emphasizing quality can actually save cost and reduce cycle time."

As a positive sign from the defense domain, we now find acquisition achieving an increasing level of recognition in the DoD. A new emphasis on commercial off-the-shelf (COTS) equipment and software, for example, along with renewed commercial prioritization, simplified regulations, and a preference for commercial specifications and standards exemplify this recognition (FASA, 1994; FARA, 1996). In addition, the DoD acquisition regulation is modeled on "sound business practices" (Department of Defense, 1996). We also note increasing defense partnerships with industry (e.g., Cole, 1997), less reliance

on a shrinking defense-unique industrial base (Gansler, 1998), process reengineering (Nissen, 1997), electronic commerce, and other advanced initiatives occurring in the DoD (Bryan, 1998) with much the same intensity that we observed in industry a few years back. Indeed, realizing the importance of acquisition, the former Secretary of Defense challenged the Acquisition Workforce to effect a 50 percent reduction in cycle time to develop and field major weapon systems (Perry, 1994). This represents a call for radical change of reengineering proportions (Hammer and Champy, 1993).

Again, referring to the "tooth versus tail" metaphor, the argument now appears outdated. Regardless of the number and size of one's teeth, one can run only as fast and as long as one's tail allows. Notwithstanding our breathtaking military performance in the Gulf War, for example, armored units were restrained by the logistical chain. Our ability to strike with overwhelming force required patience and persistence as we amassed troops, supplies, and battlefield assets in nearby countries. Even our theater information systems were critically dependent on relationships with commercial vendors for equipment, software, and bandwidth in the region. With slow, bureaucratic, cumbersome, inflexible, and unresponsive procurement and logistics processes, battlefield speed is severely constrained after the first few days of intensive conflict.

"Notwithstanding our breathtaking military performance in the Gulf War, for example, armored units were restrained by the logistical chain."

Recently, the Secretary of Defense set forth an incisive, change-oriented strategic plan titled "Leading Change in a New Era" (Cohen, 1997), in which he acknowledges that acquisition (especially procurement and logistics) now limit battlefield information, mobility, and speed. Thus, in much the same way that the scope and pace of change have elevated acquisition to a level of strategic importance in industry, we see the acquisition process on the verge of becoming *strategic* to the military. Acquisition? Strategic? In the military? This represents a radical concept for the DoD, a concept that calls for concomitant revolution in defense acquisition as well as in military affairs. But how do we manage such radical organizational change of unprecedented scope, pace and importance? It is clear to the authors that simplistic, "quick-fix" approaches or recirculating old ideas under new labels will not suffice. Rather, far from business-as-usual and the status quo, substantial new acquisition knowledge is required, and is required now.

Purpose of this Special Issue

The purpose of this Special Issue is to catalyze the quality and quantity of new acquisition knowledge produced through scholarly research. Although research represents only one of several important knowledge sources—others include, for example, professional practice, trial and error, and lessons learned—it is arguably the most neglected at present and the most critical for the future, particularly at this time when "outside-the-box" thinking and radical process redesign are called for. As

the principal outlet for published acquisition research, the *Acquisition Review Quarterly (ARQ)* represents an ideal venue for promoting and disseminating new acquisition knowledge. But in the same way the DoD has begun to look beyond current boundaries for new ways of operating, our purpose in this Special Issue is to reach beyond the boundaries of current *ARQ* participation. Specifically, we wish to target scholars in universities and other research institutions outside the government and engage their interest in defense acquisition as a primary area of research. As our subsequent discussion will indicate, those researchers represent a tremendous potential resource for realizing improvements in acquisition. For instance, they work according to high standards of scholarship that can help advance the state of acquisition knowledge. And they can integrate knowledge from multiple disciplines (e.g., economics, information technology, politics) to increase our understanding of and provide solutions to acquisition problems. Yet there is little evidence that these non-government resources are interested in wrestling with key acquisition issues.

No doubt one of the main reasons for this condition is that leading researchers are motivated principally to publish their work in the top academic journals of their respective disciplines. Thus, we proposed the idea, which the *ARQ* editors graciously endorsed, of this Special Issue specifically to capture the interest of research scholars from beyond the current, tiny pool of top-notch contributors. Two key features of the Special Issue were deemed necessary to accomplish this. First, we selected a "non-DoD-specific" theme or topic to attract scholars from a wide range of disciplines; hence the neutral topic "Managing Radical Change." Second, we set forth the same high research standards that leading scholars follow to publish in the top academic journals of the land. Of course, publicizing the Special Issue project beyond *ARQ*'s current boundaries was also necessary to accomplish our goal. Along with extensive dissemination of the "Call for Papers," we actively solicited more than 1,000 scholars to submit manuscripts to the Special Issue. To enforce high standards of scholarship, we recruited many others to serve as journal referees. In summary, we hope these steps will enable the Special Issue to reach a much wider academic audience than the customary *ARQ* readership. In particular, we hope it will engage top-flight researchers who previously may have seen little interest in acquisition research and publication, particularly defense acquisition. But we should make it plain that our intent in this Special Issue is not to "reinvent" *ARQ* as a journal for non-government academics. We see no reason why the journal should not remain, as then-Defense Acquisition Executive John Deutch put it in his introduction to *ARQ*'s inaugural issue, the premier acquisition publication within the government

"...we actively solicited more than 1,000 scholars to submit manuscripts to the Special Issue."

> ...to integrate the professional interests of the varied and diverse acquisition career fields, to infuse senior managers with a sense of community and common purpose, *and to provide a forum for scholarly debate...*.(Deutch 1994, 4; emphasis added).

We do, however, assert and will argue that it is this last component of Mr. Deutch's vision—the aspect of *scholarship*—that is most lacking in defense acquisition research, and subsequently in *ARQ*. Hence, we seek in this Special Issue to help make *ARQ* all that its founders envisioned it to be.

IMPLICATIONS OF RADICAL CHANGE FOR ACQUISITION RESEARCH

As we approach the 21st century, we find ourselves facing a new military environment (e.g., expanding mission requirements, declining defense funds, absence of a monolithic superpower threat); one which calls for new acquisition processes. The nature, scope, and pace of change required to effectively transform these acquisition processes imply that new knowledge will be required. Change of such magnitude and speed are unprecedented within the defense acquisition system; hence leaders cannot simply reuse old ideas and techniques. Rather, these new processes require new knowledge—theoretical knowledge to guide high-level policy— and decision-making; applied knowledge to support transition and execution in the new acquisition environment; and reliable, generalizable, cumulative knowledge to leverage problem solutions across many defense programs and avoid redundancy or duplication. New acquisition knowledge such as this calls for research, because the researcher's primary motivation is knowledge creation (discovery research).

"The nature, scope, and pace of change required to effectively transform these acquisition processes imply that new knowledge will be required."

Further, researchers have a unique ability to generalize from experiences. They build cumulatively upon the work of others and employ rigorous methods to ensure high validity and reliability of their results. In his classic work, Kuhn (1970) refers to this invaluable work as "normal science," or the cumulative accretion of knowledge by researchers within an accepted paradigm (e.g., Newtonian physics). But researchers also perform what Kuhn calls "revolutionary science," as exemplified by the "paradigm shifts" from Newtonian to Einsteinian physics, or from Ptolemaic to Copernican astronomy. It is next to impossible to achieve paradigm shift without research of a relatively fundamental, loosely applied nature, and absolutely inconceivable to attempt such a shift through incremental changes in acquisition practice alone; that is, without research.

Indeed, only research that stretches the boundaries of current knowledge can be used to leverage solutions across entire *classes* of problems (e.g., through new theory) and to adapt effective solutions induced from one process or program to many others. And academics are trained to design experiments and employ rigorous research methods that isolate effects and minimize the cost of knowledge creation. Such research requires careful planning and preparation and is time-consuming. But it minimizes exposure to failure from trial and error (e.g., as with professional practice, on-the-job training, lessons learned, and so on) and maximizes the impact and dependability of results per

unit cost. Thus, academic research is both efficient and effective at knowledge creation. By building on the cumulative work of others, researchers are able to avoid the redundancy, duplication, and waste that plagues many current acquisition reform efforts in practice. Of course, research also feeds education, training, consulting and, ultimately, professional practice itself, as new knowledge creation (i.e., research) sits at the top of the knowledge hierarchy.

We certainly do not wish to suggest that the acquisition domain has been entirely devoid of research in the past. Scholars from many disciplines write on topics that, while not "acquisition-specific," are central to acquisition. Aaron Wildavsky's work (1969) in budgeting and policy analysis is but one example. Acquisition even has a few of its own distinguished scholars, probably the most well-known of whom is J. Ronald Fox (1974; Fox and Field, 1988). Nor do we suggest that, institutionally, the DoD has completely neglected acquisition research. Past attempts to enhance acquisition research include establishment of the Army Procurement Research Office in 1969, the Procurement Research Coordinating Committee in 1971, the Federal Acquisition Research Symposia in 1972, the Air Force Business Research Management Center in 1973, the Federal Acquisition Institute and the Naval Center for Acquisition Research in 1977 (Office of Management and Budget, 1980). Further, we recognize that others before us have documented issues of acquisition research methods, sources, products, quality, and scholarly rigor (Strayer and Lockwood, 1975; Martin *et al.*, 1978), as well as the potential benefits to DoD of the contributions of university researchers (Strayer and Lockwood, 1975; Abellera, 1993).

These points notwithstanding, acquisition research remains a marginalized activity. The percentage of non-government academics—most of whom do not require external research funding—working on defense acquisition research topics remains relatively low. The top minds employed by leading research institutions simply pay negligible attention to critical problems of defense acquisition. We may attribute this in part to our society's historical tendency to draw distinctions between military and civilian matters, and to the separate identity of the military created by its unique role and ethic. These can lead to an ignorance—perhaps even a distrust or fear—of military matters among non-government scholars (Jefferies, 1977). At the very least, such perceptions indicate to scholars that defense is "different."

"The top minds employed by leading research institutions simply pay negligible attention to critical problems of defense acquisition."

Exacerbating this situation is that much of the acquisition research currently performed within DoD tends to be applied research and lacks rigor. This is not to imply that applied research is less valuable than basic or exploratory work, but research is governed by a well-understood maxim: The more applied the work, the more narrow the benefits of its results. By contrast, the more fundamental the work, the wider the coverage of benefits.

Further, unless research is conducted with the kind of rigor demanded by top academic journals, the results risk

duplication with previous efforts (e.g., if not guided by a thorough literature review), confounding of causal effects (e.g., not being able to assess a particular result to decisions made or actions taken), non-generalizability (e.g., results that apply only to the specific case, process, program, or system studied) and other threats to validity (e.g., rival hypotheses, concept invalidity, unreliability; see Campbell and Stanley, 1973; Yin, 1994). Research that tends to be applied and which is conducted with little rigor is classified as "1–1" and "2–2" work using the research framework depicted in Figure 1 (Acquisition Group, 1997).

Briefly, on the horizontal axis we have the fundamentalism or "basic-ness" of the research, which corresponds roughly to the standard research categories used in the DoD-management and support, engineering development, advanced development, exploratory research, and basic research (see Fox, 1974; p. 22). As depicted by the five-point scale for this axis, work toward the extreme end of the scale characterizes research of a more fundamental and general nature, which seeks to solve broad classes of problems in a domain of investigation. As research moves toward the origin along this dimension (i.e., becomes increasingly applied), the associ-

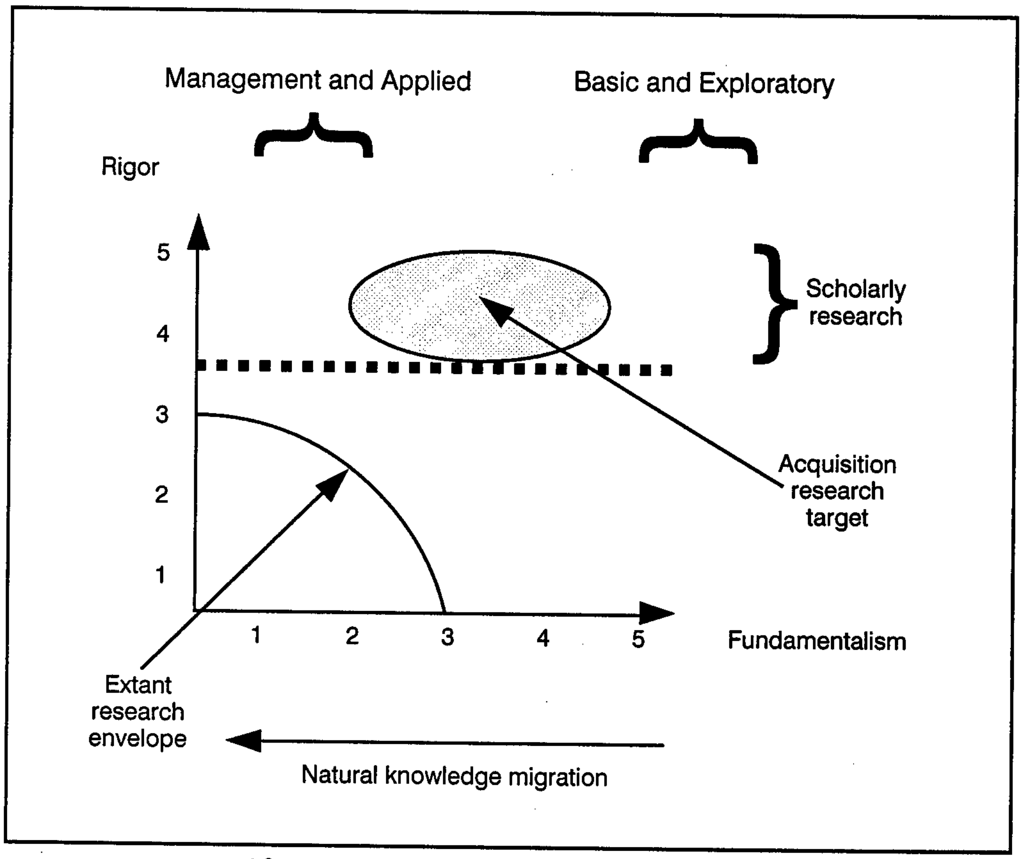

Figure 1. Acquisition Research Space

ated research takes on a narrower, more specific, shorter-term character. This helps to depict the natural migration of research from the basic and exploratory development of new knowledge toward management and applied work as research in an area matures. This dynamic pattern also highlights the need for systematic introduction of new knowledge and ideas—that *derive* from more fundamental investigations—through applied research. Indeed, without such fundamental (e.g., basic, exploratory, developmental) research, a program based solely on applied work will eventually stagnate and regress into a pattern of recirculation. In fact, a number of scholars perceive this pathological pattern existing in the acquisition domain today (Williams and Arvis, 1985).

Returning to the research space diagrammed in Figure 1, the ordinate is used to depict the methodological rigor associated with research (in any category, basic or applied). This five-point scale is used to classify the increasing use of high-confidence research methods that leave decreasing margin for refutation of the results. For example, work at level 1 (i.e., lowest level of rigor) may involve an investigator who is not even objectively detached from the work being studied (e.g., a knowledge worker who merely reports the results of his or her acquisition work). At level 2, an *independent* investigator is at least in a position to objectively observe and describe some acquisition phenomenon of interest. At level 3, this independent investigator conducts a thorough *literature review* in a particular area, in order to avoid duplicating previous results and to focus on the kinds of high-payoff research targets and topics that can only be identified through an understanding of, and appreciation for previous work in a research area. At level 4, the investigator ensures *generalizability* of the results by employing a well-founded research design (e.g., multiple case study, factorial, stratified survey). At level 5, the researcher may even employ experimental (or quasi-experimental) methods—like those stressed in the physical sciences—in order to promote the highest levels of confidence in the results.

Two main points emerge from this diagram. First, the majority of extant research in the acquisition domain would be classified near the origin of this research space, as depicted by the "extant research envelope" in Figure 1. This tends to represent just POK (plain old knowledge) work and specialized consulting more than what most academics would even consider to constitute "research," and it suffers from high refutability and lack of generalization. Although the contribution of such work is positive, it is minimal in that it tends to address only one specific problem at a time, is often redundant with previous or parallel work, and offers results confounded by poor methodology. This arguably represents a suboptimal allocation of scarce research resources. Second, any acquisition research—whether basic or applied—needs to be scholarly to overcome the refutability and generalization problems from above. These points are used to establish the acquisition target

"...without such fundamental (e.g., basic, exploratory, developmental) research, a program based solely on applied work will eventually stagnate and regress into a pattern of recirculation."

research area depicted above the horizontal, "scholarly research" line in the figure.

The discussion intimates that the more fundamental the research and the higher the rigor of its methods, the greater the leverage effected to solve broad classes of problems that result in an efficient expenditure of funds and address the concerns of the many over the problems of the few. To accomplish such research, the best minds, tools, and methods must be applied to DoD acquisition problems. Many of these are currently engaged in research that is not specific to DoD, but which is applicable or can be adapted to DoD, such as commercially oriented work. Large corporations, like DoD, have to acquire materiel and supplies in the face of financial constraints, schedule deadlines, global logistics, and uncertain planning horizons. It is conceivable that a robust research program can reach out to top researchers with a commercial orientation and help them adapt their current, fundamental, and scholarly (i.e., "4–4" and "5–5") work to defense acquisition topics. It is equally conceivable that defense acquisition executives and practitioners can learn from commercial practice as well. Indeed, if we in acquisition want to "do business more like business," perhaps we should be tapping into research that is oriented toward the more general business problems. That is, we should do research more like researchers.

"It is conceivable that a robust research program can reach out to top researchers with a commercial orientation and help them adapt their current, fundamental, and scholarly (i.e., "4–4" and "5–5") work to defense acquisition topics."

New Directions

Regarding new directions in acquisition research, we note three recent efforts: 1) the Defense Acquisition University (DAU) acquisition research thrust, 2) the *Acquisition Research Quarterly* publication as a refereed journal, and 3) the Naval Postgraduate School (NPS) program of acquisition research. We briefly outline each of these efforts in turn and discuss an approach toward their integration.

DAU research. In addition to training and education, the DAU is also chartered to conduct acquisition policy research. For the past few years, the Acquisition Research Coordinating Committee (ARCC)—represented by each of the dozen or so DAU consortium schools—has been working to define and initiate a program of acquisition research. The DAU Board of Visitors is actively pushing to establish an external research program to include many of the same kinds of world-class research institutions noted earlier as needed for the development of new knowledge in the acquisition domain. Indeed, the DAU is outlining such an external acquisition research program at the time of this writing. The emergent DAU program is clearly consistent with many of the needs and approaches articulated through this article.

***ARQ* publication.** The *ARQ* is a relatively new journal, which was established in part to fill an important gap in the publication of acquisition research. As a refereed publication, the *ARQ* has put into place the necessary infrastructure,

policies, and procedures that are required to ensure high standards and attract leading academics and other researchers. Because publication continues to represent one of the primary objectives of the academic research community, the existence of this outlet for *acquisition* research represents a necessary condition for the kinds of new knowledge creation called for in this article. Publication of this Special Issue indicates a lucid focus on the current state of research in the acquisition domain.

NPS acquisition research program. Faculty from the NPS Acquisition Group have been pursuing their individual research agendas for some time, but they recently outlined and composed a five-year program of acquisition research to integrate the disparate efforts (Acquisition Group, 1997). Focused on the integration of acquisition reform and process innovation, this research program is, we believe, in line with the kinds of new knowledge needs identified earlier. The NPS agenda is also entirely consistent with the emphasis of the DAU external research program, in that it too stresses collaboration with top researchers from leading, non-government universities and institutions around the world. NPS is recognized as a peer research institution of these leading universities. Yet its faculty provide a unique understanding of the DoD, along with the ability to integrate and adapt non-DoD-specific research to address problems with relevance to defense. In essence, this is how the Special Issue came to be.

Integration. Clearly, some time will be required to integrate these three efforts, but the time to start is now. Given the lag between research ideas and results, it will probably take several years to establish a robust, interdisciplinary, multi-institutional program of acquisition research that attracts the best work of the best people. But once we encourage the top minds to begin working on acquisition problems—priming the pumps, by analogy—we can begin to reap the benefits of scholarly research, and then continue year after year. Further, once we interest university researchers in working on these problems—and find leading journals publishing their results—we will have catalyzed a broad, multidisciplinary research program that requires little in the way of recurring funding. By catalyzing such a research reaction, we see the opportunity to leverage a relatively small funding level into multiplicative levels of effort in the university system. For example, an acquisition research study (Abellera, 1993) found that 95 percent of university-conducted acquisition research was *not funded* directly by the DoD; rather, of every 20 studies conducted, 19 were funded by the research institutions themselves. This characterizes the central advantage of *catalyzing* a program of external acquisition research, as opposed to funding one directly (i.e., 20:1 leverage of funded results).

> **"But once we encourage the top minds to begin working on acquisition problems—priming the pumps, by analogy—we can begin to reap the benefits of scholarly research, and then continue year after year."**

Specifically, most leading universities pay their top researchers a salary and do not require outside funding for them. The researchers' interests accordingly focus on publishing their results in leading journals. Even a small investment in such academics

can give them incentives to conduct research on acquisition topics yet still publish in leading journals. In many cases, these researchers can easily adapt their work to defense-related topics. For example, General Motors has a supply chain to manage, Intel is concerned with technological infrastructure, AT&T has global communications concerns, WalMart must manage efficient logistics, Microsoft is principally composed of knowledge workers and knowledge capital, and so forth. Our challenge is to assist researchers with the adaptation of commercial acquisition knowledge such as this to the defense domain. Through such assistance we can further leverage previous work to apply across a broad class of military problems, systems, and applications.

In fact, we actively seek out top researchers who understand DoD, but who are not constrained by this understanding. We are interested in researchers at leading universities who can conduct first-class research on DoD acquisition topics, *and* publish their results in top-tier academic journals. Unfortunately, to date we have identified surprisingly few such people. Yet we did in fact receive a number of excellent manuscripts in response to our "Call for Papers," and we actively worked with authors from leading universities—most of whom were somewhat unfamiliar with the defense acquisition world—to adapt their work to acquisition-specific topics. Indeed, the number of manuscripts received was sufficient to discard many papers that failed to meet our high standards for this Special Issue on "Managing Radical Change."

"We are interested in researchers at leading universities who can conduct first-class research on DoD acquisition topics, and publish their results in top-tier academic journals."

Editorial Perspective on the Special Issue

To attract research scholars, we set for the Special Issue certain standards that were consistent with those of top-flight academic journals. With regard to manuscript content, we generally sought theoretical and empirical work that would advance the understanding and explanation of acquisition, as it is broadly defined. With regard to procedure, we employed a rigorous, double-blind review process. We specifically recruited reviewers who themselves have published research in scholarly journals. Thus, we were able early on in the process to eliminate from consideration several submissions that represented work of the "1–1" or "2–2" classes alluded to earlier. Most of the articles contained herein underwent at least three revisions, which is testimony to the contributions and thoroughness of our referees (and also to the patience of the authors!).

A large portion of our work as editors entailed negotiating and enforcing the Special Issue theme of "Managing Radical Change," in addition to our demand for relevance to defense acquisition. As editors, we had little interest in manuscripts that were either DoD-myopic or in no way applicable to DoD. Nor didd we have interest in submissions that were unrelated to the contemporary environment of radical change. But of course few scholars have done work that spans these

research contexts. As a consequence, much of our substantive editorial work consisted of suggesting conceptual avenues that authors could pursue to relate radical change to acquisition and vice versa; that is, the very kind of assistance with defense-adaptation described earlier.

In reviewing the fruits of this roughly nine-month project, we are satisfied. In response to both the "Call for Papers" and solicitations through our academic networks, we received manuscripts from researchers at seven different colleges and universities, as well as a couple of submissions from practitioners. A diversity of scholars from several different academic institutions served as reviewers. All told, more than a dozen institutions are represented in some way in the Special Issue. The great majority of our participants had little if any prior exposure specifically to defense acquisition research; fewer still had knowledge of *ARQ*. Thus, we believe the Special Issue has been successful, even if it has served only as a "consciousness-raising" vehicle for those involved.

Of course, the works of the Special Issue authors represent significantly more substantive contributions. The seven articles that passed the review process span a diversity of academic disciplines, yet all bring knowledge and research to bear on acquisition issues and on the theme of "Managing Radical Change." Thus, we do not intend the order in which the articles appear to represent any gradation in merit. The order simply reflects our collective opinion as to which articles fit best together and provide the most sensible conceptual flow.

The first three papers deal with "people" aspects of radical change and acquisition. Professor Nancy Roberts leads off, and early in her article she provides a conceptual framework for understanding radical change, which serves as a useful introductory context for the entire Special Issue. Professor Roberts then proceeds to investigate one specific way that radical change can occur—by entrepreneurial design—and its implications for reform of defense acquisition processes.

"The seven articles that passed the review process span a diversity of academic disciplines, yet all bring knowledge and research to bear on acquisition issues and on the theme of "Managing Radical Change."

In the next article, the focus shifts from entrepreneurship to leadership. Kathleen Reardon, Kevin Reardon, and Alan Rowe also provide a useful model of radical change, this one in terms of the stages of its occurrence. Their analysis integrates leadership concepts and their own empirical work on leadership styles to develop an understanding of which particular style or styles may be most appropriate and effective at each of these various stages of change.

In the third article, we move from the personal to the interpersonal. Susan Hocevar and Walter Owen place integrated product teams (IPTs) in defense acquisition within the frame of the rich management theory on teaming. Using the Navy's F/A-18 program to illustrate the implementation of recent IPT policy initiatives, they identify specific ways in which theory can inform both the policy and practice of teaming in acquisition organizations.

The next three articles deal with technology and techniques associated with

radical change in acquisition. Judith Gebauer, Carrie Beam and Arie Segev begin this set by addressing what is arguably the central feature of technological change in contemporary society—the Internet. Their article on purchasing via the Internet uses empirical results to document current practices, examine emerging trends, and assess their possible implications for the future in defense acquisition.

Walter Scacchi and Barry Boehm follow with perhaps the most conceptually radical paper in the Special Issue. Drs. Scacchi and Boehm propose a framework for virtual systems acquisition for DoD software-intensive systems, arguing that such an approach avoids many of the usual challenges and obstacles to successful development of these systems. They also explore some of the transitional issues that might be encountered by DoD in moving toward such an approach.

"We had hoped to attract many manuscript submissions from academic researchers as a result of the 'Call for Papers,'"

In the next article, Professor Gregory Hildebrandt notes that, despite the need for radical change of unprecedented scope, pace, and importance, one cannot ignore the inescapable laws of economics when establishing policy. Writing from an economics-in-contracting perspective, Professor Hildebrandt draws from well-established DoD performance-incentives policy and models to demonstrate the applicability and utility of such incentives in the contemporary acquisition environment.

The editors agreed that Dr. Lauren Holland's article should close our Special Issue, which acknowledges the paper's special message. Dr. Holland reminds us that, despite the environment of and calls for radical change, acquisition in the United States occurs in a distinctly political context. In her article she integrates two of the prevailing explanations of why acquisition reform has eluded us, and she argues that substantive change can occur only to the extent that we recognize, and perhaps even embrace, the fundamentally democratic aspects of our acquisition environment.

Closing Comments

A quick "content analysis" of Special Issue participants is appropriate. We had hoped to attract many manuscript submissions from academic researchers as a result of the "Call for Papers," which appeared in numerous scholarly journals in a wide variety of disciplines. Indeed, we wondered whether we could muster sufficient resources in terms of reviewers and editorial time to handle what we hoped would be an onslaught of manuscripts submitted. But the fact is, response via the "Call for Papers" was underwhelming. Two of these submissions were from acquisition practitioners, who most probably read the call in *ARQ*. Further, of the seven accepted papers, only one originated in response to the call. (We were informed that the authors had seen the call in an issue of *Academy of Management Review*.)

Three of the seven accepted articles were written by colleagues at the Naval Postgraduate School. The others were written by colleagues at other universities with whom we had worked in the past or whose work was familiar to us.

Thus, each of the six accepted papers was written in response to a personal contact and solicitation by one of the editors, not in response to the call for papers.

These findings reinforce our earlier comments about the "state of the discipline" regarding defense acquisition. While we can't say with confidence there is a dearth of researchers concerned about acquisition in academe, it certainly appears that there are very few who are interested in publishing in *ARQ*. The authors whose work appears herein represent a small portion of what is no doubt a vast, untapped pool of potential research resources. Yet, for the most part, these scholars had to be engaged to participate in the Special Issue on an informal, personal, and *ad hoc* basis. There simply exists no effective formalized mechanism for bringing their work to bear in the realm of defense acquisition.

We hope the Special Issue can help make this mechanism a reality. Certainly the advent of *ARQ* and the institution of DAU's Acquisition Research Coordinating Committee several years ago were appropriate and necessary first steps. We believe DAU's recent initiatives to energize and fund external research efforts hold much promise over the long term. We encourage others to join us as we continue to seek out new ideas on how closer linkages between DoD acquisition and academe may be developed and institutionalized.

In closing, we want to thank our friends and colleagues who participated in this Special Issue project. We gratefully acknowledge our reviewers, whose names are listed below, and applaud their hard work and intellectual diligence in helping to make each paper the best that it could possibly be. We also warmly thank Dr. Jim Price for his continual enthusiastic support for our work, as well as the members of his staff, particularly Mr. Greg Caruth, Ms. Debbie Gonzalez, and Ms. Norene Blanch. Last, but certainly not least, we thank all the authors who submitted manuscripts; without them, the rest of us would have had nothing to review, edit, or publish.

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RADICAL CHANGE BY ENTREPRENEURIAL DESIGN

Nancy C. Roberts

This article offers a conceptual framework to understand radical change. It opens with a typology that defines change in terms of its pace and scope, and defines radical change as the swift transformation of an entire system. How radical change in public policy has occurred in the past is then documented. We find examples of radical change by chance, radical change by consensus, radical change by learning, and radical change by entrepreneurial design. Radical change by entrepreneurial design then becomes the focal point, in order to acquaint the reader with the strategies and tactics of well-known entrepreneurs who have been successful in molding and shaping the radical change process. The implications of this conceptual framework to acquisition reform conclude the paper, along with some suggestions for follow-on action.

Explaining change and how it occurs has been a central theme in management and related disciplines. In a recent literature search using change and development as key words, researchers found more than a million articles on the subject in the disciplines of psychology, sociology, education, business, economics, as well as biology, medicine, meteorology, and geography (Van de Ven and Poole, 1995). We know from this research that concepts, metaphors, and theories used to investigate change have yielded a rich, diverse theoretical landscape. Yet, at the same time, such diversity often has confounded rather than enlightened. It is difficult to compare and contrast theories and their results, let alone work out the relationships among them, when different units, levels of analysis, time frames, and perspectives are employed.

Ideally, it would be useful to have a basic road map to guide us through the conceptual maze. While no map could possibly cover the entire terrain, one that puts the major elements of change into relief would be of advantage. That is the intention of this article. The goal is to provide an overview of change—its definition, scope, pace, and processes, with particular attention paid to radical change given the focus of this Special Issue. We seek to answer such questions as: "What is change? What are the types of change? How does change occur?" in order to inform the efforts to dramatically transform

acquisition policy and process. While acquisition reform is not in the foreground of this analysis, it certainly provides the impetus and rationale for this endeavor.

We begin with a conceptual framework that provides the backdrop for our understanding of radical change. We introduce four types of change that are differentiated by two dimensions—the pace and the scope of change. Building on these two dimensions, radical change is defined as the swift, dramatic transformation of an entire system. In the next section, we explore alternative explanations of how radical change occurs. Here the attention shifts to how change happens rather than what actually is changed. Four radical change processes are examined: radical change by chance, radical change by consensus, radical change by learning, and radical change by entrepreneurial design. We explore radical change by entrepreneurial design in the next section, since the overall focus in the symposium is how individuals can influence the radical change process. The intent is to outline various strategies and tactics that well-known public entrepreneurs have employed to affect radical change. The article concludes by identifying the conceptual framework's most important implications for acquisition reform, such as whether radical change in acquisition can be pursued and who would be the likely public entrepreneurs leading the charge.

CONCEPTUAL FRAMEWORK

Change is an empirical observation of difference in form, quality, or state over time in an entity (Van de Ven and Poole, 1995). Entities can be such things as a product, a job, a program, a strategy, a person, a group, or an organization. Acquisition policy is one such example. Observing a difference in its form, quality, or state at different points in time, we would say a change had occurred. And note that we are not attributing a value to that change (whether it is good or bad)—only that it has happened.

Change is often examined in terms of its pace and scope. Pace refers to the speed at which change occurs. It is a relative concept that has to be embedded and interpreted within a particular context. The hundred years it took to change from an

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agrarian society to an industrial society (the Industrial Revolution in Britain) is a very short time if one examines it against the backdrop of thousands of years of geological, biological, and human history. Or in the instance of acquisition, a policy that emerges over multiple administrations can be characterized as slower when compared to policies that are put in place by the stroke of one presidential pen.

Scope delimits the range of possibilities in an entity. For example, are we examining the change of an entire organization or are we examining one aspect of change in the personnel department? Or in the case of acquisition policy, are we referring to the entire policy or only a subset that pertains to a particular regulation or routine? Thus, scope can be viewed in terms of parts or wholes. Are we attempting to change the whole entity or only one of its many subsystems?

Scope and pace, if treated as two dimensions of change, produce four different types of change (Figure 1). ***Element adaptation*** refers to minimal modifications in one part of the system to ensure that the part is in better alignment with the system's other elements. It is a movement of convergence rather than divergence for the purpose of improving the system's overall functioning and efficiency. The assumption is that unless all the system's parts are aligned with one another, the system will not be operating at its optimum level. Since the alignment evolves over time in continuous steps as modest adjustments are made to one part of the system and then another, the pace is characterized as slow rather than fast. This type of change is often referred to in the literature as first-order change (Watzlawick, Weakland, and Fisch, 1974), branch change (Lindblom, 1959), evolutionary change (Greiner, 1972), single-loop learning (Argyris and Schon, 1978), continuous change (Meyer, Goes, and Brooks, 1993), incremental change (Tushman and Romanelli, 1985), and momentum change (Miller and Friesen, 1980). It describes modest adjustments by small degrees to parts of an existing system which itself remains unchanged.

System adaptation refers to a change in the system itself rather than a modification in one of its parts. It often is characterized as a discontinuity or a jump from an initial system to a new one. Representing

		Scope of Change	
		Part	**Whole**
Pace of Change	**Slow**	**Element Adaptation**	**System Adaptation**
	Fast	**Element Transformation**	**System Transformation**

Figure 1. Typology of Change

a qualitative rather than a quantitative shift in the way things are done, it is marked by divergence rather than convergence. Instead of a focus on the alignment of a system's part to improve system efficiency, as in the instance of element adaptation, the purpose is to realign the parts to form a new whole in order to achieve system effectiveness. However, since this new system emerges in continuous steps over a longer period of time, its pace is also characterized as slow rather than fast. The Industrial Revolution provides one example. Subsystem changes in production, agriculture, education, urbanization co-evolved and emerged over a period of years, and ultimately yielded a dramatic reconfiguration of society as a whole.

"It is possible to combine types of change into an overarching theory of change."

Element transformation refers to a dramatic shift in a system's part in a relatively short period of time. The system itself does not undergo a radical reconfiguration, but only a subsystem or element. Evidence of element transformation can be seen in the introduction of a radically new computer system to an organization. Expected to enhance the organization's ability to handle information flow and to increase its efficiency, the new computer system is not intended to have a spillover affect in the rest of the organization. The plan is to have the organization's other elements continue to operate as they always have. Thus, the radical change is localized in one element of the organization and does not extend to all of its parts or the whole.

System transformation represents a dramatic break from one system to another in a very short period of time. It is characterized by a change in the system itself rather than a modification of one of its parts. Recent examples at the national level come from New Zealand's dramatic transformation from a command economy to a market economy and the Soviet Union's shift from a totalitarian to a democratic state. The literature refers to this type of change as root change (Lindblom, 1959), radical change (Tushman and Romanelli, 1985), revolutionary change (Gerlach and Hines, 1973) transformation (Hernes, 1976), double-loop learning (Argyris and Schon, 1978), paradigm change (Sheldon, 1980), quantum change (Miller and Friesen, 1980), and discontinuous change (Nadler, Shaw, and Walton, 1995). Throughout the rest of this article we will refer to this type of change as radical change.

These four types of change drawn from the above typology are not necessarily mutually exclusive. It is possible to combine types of change into an overarching theory of change. For example, the theory of "punctuated equilibrium" views change as the alternation between long periods when stable infrastructures permit only incremental adaptations (as in element adaptations), and relatively brief periods of revolutionary upheaval marked by discontinuous change (as in system transformation) (Gersick, 1988; 1991; Kuhn, 1970; Prigogine and Stengers, 1984; Tushman and Romanelli, 1985). Baumgartner and Jones (1991) found evidence of punctuated equilibrium when they examined public policies from a historical perspective. Many policies went through long periods of stability punctuated by short periods of dramatic change. The "grand lines of policy" are often settled, sometimes for

decades, during these critical periods of disequilibrium when old policy values and assumptions are challenged and displaced by radically new ones. Thus, as in the case of punctuated equilibrium, one type of change can combine with another to yield a more complex theory of change.

The Process of Radical Change

Thus far we have examined change from the vantage point of pace and scope and defined radical change as a swift, dramatic transformation of an entire system. Change also can be explored in terms of its dynamics (how it occurs rather than what actually happens.) From a process perspective, the interest is in the sequences of events and the generative mechanisms that drive the process to explain how change unfolds. Our unit of analysis for this inquiry will be the domain of public policy rather than any one organizational entity since acquisition reform spans multiple organizations and contexts.

When we examine the dominant models to explain changes in public policy, we find that most are devoted to the exploration of slow, adaptive changes rather than radical, transformational changes. Instead of focusing on major shifts in a system, or the dramatic turn of policy events, attention is drawn to explaining the continuity of public policy and the relatively small adjustments made to the status quo (Lindblom, 1959; Cobb and Elder, 1983; Ripley and Franklin, 1991). The emphasis is not surprising. As Herbert Kaufman reminds us, "the logic of collective life has a conservative thrust; it lends authority to the system as it stands" (1971, p. 10).

Yet we do find instances of system transformations occurring in public policies. British and Swedish welfare policy was fundamentally altered during the first several decades of this century (Heclo, 1974). During the mid-1970s in the United States, there were major policy shifts under way concerning clean air (Jones, 1975), tobacco (Fritschler, 1989), deregulation (Derthick and Quirk, 1985), pesticides (Bosso, 1987), and nuclear power (Campbell, 1988). The question we now turn to is how these system-wide transformations occur. How is the stability of the old policy order broken and a new, qualitatively different policy put in place? In this section, we summarize four processes taken from the policy literature that attempt to explain the dynamics of radical policy change: radical change by chance, radical change by consensus, radical change by learning, and by radical change by entrepreneurial design. Of particular interest is the design perspective, which treats political actors as capable of taking strategic, transformative actions and managing the change effort.

> **"When we examine the dominant models to explain changes in public policy, we find that most are devoted to the exploration of slow, adaptive changes rather than radical, transformational changes."**

Radical Policy Change By Chance

Using a revised version of the Cohen-March-Olsen (1972) garbage can model of organizational choice, John Kingdon

(1984) conceives of three process streams to describe the policy arena. There are streams of problems, policies, and politics, each largely independent of one another and each developing according to its own dynamics and rule (p. 20). Policies are generated whether or not they are solving a problem; problems are recognized whether or not there is a solution; and political dynamics move along at their own pace. The greatest policy changes occur when the three streams (policy problems, policy ideas, and proposals) are joined through a choice opportunity, or "coupled into a package" (p. 21). This serendipitous linkage often relies on policy entrepreneurs "for coupling solutions to problems and for coupling both problems and solutions to politics" (p. 21). Indeed, "the appearance of a skillful entrepreneur enhances the probability of a coupling" (p. 217). While not completely random, dramatic policy changes rely on "considerable doses of messiness, accident, fortuitous coupling, and dumb luck" (p. 216). They are often prompted by dramatic shifts in the socio-political-economic context that alter constraints and opportunities for policy actors. We have examples of such shifts in the Arab oil boycott of 1973–1974 and the passage of California's Proposition 13.

"While not completely random, dramatic policy changes rely on "considerable doses of messiness, accident, fortuitous coupling, and dumb luck...."

While radical change by chance keeps us humble in any change effort, ever aware of the limits to human management and control of a very complex process, the accidental, serendipitous nature of transformational change that Kingdon describes leaves little room to explore how participants might take advantage of "windows of opportunity." We are left wondering how to couple the streams of policy problems, ideas, and politics for radical change. On these aspects, the theory is mute. Thus we turn to the next theory of radical change to understand how participants might be more directly involved in the change process.

RADICAL CHANGE BY CONCENSUS

According to Wildavsky, in the United States there are three political cultures: "different shared values justifying social relations...[that] orient people to political life" (Coyle and Wildavsky, 1987, p. 3). The three are hierarchical collectivism, competitive individualism, and egalitarian collectivism (Wildavsky, 1982; Coyle and Wildavsky, 1987). Radical policy change occurs when the elites of these three political cultures find an integrative solution that meets their preferences. (They do not need to agree on exactly why the radical change meets their desires, only that it does).

Hierarchical collectivism asserts that human nature is fundamentally flawed. As a consequence, this political culture promotes the establishment of "good institutions to prevent the Hobbesian 'war of all against all'" (Coyle and Wildavsky, 1987, p. 4). Central authority is supported in all social, political, and economic spheres, since differentiation and subordination is expected to produce stability. And to ensure this stability, hierarchical collectivism promotes equality before the law.

Using the example of poverty, one would explain poverty as resulting from "failing to follow rules of proper conduct and the advice of expert authorities" (p. 5). Hierarchs, therefore, would support paternalistic social policies (e.g., food, clothing, and moral guidance to the needy) since the poor could not be trusted to look after their own interests (pp. 4–5).

Competitive individualism posits that human nature depends on circumstance. Benefits flow when human nature is allowed to be free and flourish. Thus, authority is minimized and self-regulation is promoted. Equity of opportunity is important to support competition and bilateral bargaining is viewed as the mechanism to achieve growth. From this perspective, again using the example of poverty, one could explain poverty as stemming from either personal incapacity or interference from central authorities who dampen individual initiative. Individualists maintain that it is the responsibility of each person to escape poverty; the government should not intervene to tell people how to do it (pp. 4–5).

Egalitarian collectivism maintains that "human nature is fundamentally good except when corrupted by evil institutions" (p. 4). It follows that authority is rejected in favor of giving each person equal influence. Equal influence derives from equal conditions to support equal outcomes. And substantive equality is achieved through persuasion and group unanimity. Thus, egalitarians would blame "the system"(bad institutions) that oppresses the poor in the case of poverty. They would find paternalism offensive because it implies that some are wiser than others and therefore should have more power than others. Ultimately, they would support policies that seek to redistribute incomes and resources (pp. 4–5).

One example of a radical change by consensus can be found in the Reagan administration's ability to win acceptance of a broader based, lower rate personal and corporate income tax in the 1980s (Coyle and Wildavsky, 1987). In terms of acquisition policy, we would expect radical policy change to occur if and when the elites of these three political cultures were able to develop an integrative solution or consensus on policy that met the value preferences of hierarchical collectivism, competitive individualism, and egalitarian collectivism.

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While there is more play for individual actors in this theory of radical policy change, especially among the political elites, the focus is on the reconciliation of their ideas and the compatibility of their values preferences rather than the management of the change process per se. The theory presumes that as long as value preferences among the elite are compatible, the execution of any policy would not be problematic, an assumption that the implementation literature has successfully challenged (Bardach, 1977). To understand the contributions of others in the policy change process, in addition to the activities of the elites, and to take a fuller view of the en-

tire policy process, we have to turn to the next theory of radical change.

Radical Change By Learning

Radical change by learning comes about through the interaction of advocacy coalitions—people "who share a particular belief system (i.e., a set of basic values, causal assumptions, and problem perceptions and who show a nontrivial degree of coordinated activity over time") (Sabatier and Jenkins-Smith, 1993, p. 25). Members can include researchers, analysts, journalists, administrators, interest group members, and elected officials. An advocacy coalition can produce radical change through policy-oriented learning, defined as "belief system modification" (Sabatier and Jenkins-Smith, 1993, p. 49), by generating technical information and conducting formal policy analysis. The learning process involves research and analysis on the seriousness of a problem, the search for its causes, the collection of evidence to challenge or support alternative causes, and proposed solutions that will address the problem without politically unacceptable costs. Although interaction between advocacy coalitions often produces a "dialogue of the deaf" (p. 48), it is possible for different advocacy coalitions to have a productive analytical debate and learn from each other. Learning tends to occur when there is an intermediate level of informed conflict between advocacy coalitions, when policy issues have a greater analytical tractability (i.e., have "widely accepted theories and quantitative indicators"), and when a professionalized forum exists in which "experts from competing coalitions must justify their claims before their peers" (p. 55).

"Radical change by learning comes about through the interaction of advocacy coalitions—people 'who share a particular belief system (i.e., a set of basic values, causal assumptions, and problem perceptions and who show a nontrivial degree of coordinated activity over time')."

Thus, learning by an advocacy coalition may demonstrate such deficiencies in another advocacy coalition's core beliefs such that it is possible for a system-wide shift to occur, usually at the instigation of system-wide leaders. One such change occurred when economists demonstrated over a period of 20 years the inefficiencies of government regulation of airline fares, which eventually led to the abolition of the Civil Aeronautics Board and airline deregulation. It also should be noted that such change will not come about solely due to the learning activities internal to the policy subsystem. Changes of this magnitude are usually accompanied by an exogenous shock that alters the resources and opportunities of the various coalitions (Sabatier and Jenkins-Smith, 1993, p. 220).

The studies of advocacy coalitions gives much more guidance on the process of radical change compared to the previous two process theories. The approach recommended is analytical problem solving between specialists in advocacy coalitions who have acquired the skills and knowledge of the policy domain in question. The theory is silent, however, on a number of other issues. For example, it does not specify how one is to deal with

the political dynamics that are likely to be provoked in a radical change process, especially change involving ideas and issues that are not tractable and lack a forum where experts can justify their claims among their peers. The microlevel activities also are not addressed because the unit of analysis is the coalition rather than the individual actor. For advice on how individual actors influence the political dynamics of the change process, we must turn to the theory of radical change by entrepreneurial design.

Radical Change By Entrepreneurial Design

Entrepreneurial design begins with conscious, deliberate activities of policy actors who have a radically new idea that they want to see implemented. It is a "teleological approach to change" because individuals are assumed to be capable of purposeful and adaptive behavior; by themselves or in interaction with others, they are able to envision an end state and take action to reach it, while monitoring their progress along the way (Van de Ven and Poole, 1995).

Policy entrepreneurs, as these policy actors are often called, are similar to analysts in that they seek to determine the nature of a problem and its cause, the potential range of solutions, and the most important strategy to achieve their desired outcome or idea given the available resources. However, policy entrepreneurs move well beyond the rational analytic approach to be effective agents of radical change. Ever mindful of the political realities, they are concerned with framing their ideas in the best possible light in order to attract and expand their base of support. Their strategies and tactics are designed to overcome resistance, undermine the strength of the opposition, and sell power holders on the merits of their ideas. Building a coalition and keeping it focused on their policy objective is a priority, not just through policy formulation, but also through implementation and evaluation.

We have an excellent example of radical change by entrepreneurial design in the case of choice in the Minnesota schools (Roberts and King, 1996). The idea of public school choice was initiated and designed by six policy entrepreneurs, and championed by Gov. Rudy Perpich. It was viewed as the solution to the "problem" of a bureaucratic educational system that was unresponsive to student and societal needs. "Open enrollment," as it was called, was expected to create a modified market within the public school system by enabling students to choose which public school district they wanted to attend. To push the ideas forward, the policy entrepreneurs developed an elaborate structure of activities that enabled them, over a period of four years, to convince others of the merits of their innovative idea. Although criticized as radical educational change, choice was eventually implemented and extended throughout the K–12 system in Minnesota and is now under consideration in other states as well.

"Entrepreneurial design begins with conscious, deliberate activities of policy actors who have a radically new idea that they want to see implemented."

Thus, of the four theories of radical change, only the fourth really explores

how individuals can influence and mold the change process. The next section explores the range of entrepreneurial activities and demonstrates how successful entrepreneurs are able to create opportunities and minimize constraints as they fight their way through the change process.

POLICY ENTREPRENEURS AS AGENTS OF RADICAL CHANGE

Research has uncovered a wide-ranging set of activities in which policy entrepreneurs and change agents engage. They employ rhetoric, symbols, and analysis to frame the policy problem in a way that promotes their views and their preferred solution (Baumgartner and Jones, 1991; Riker, 1986; Stone, 1980). They are students of the policy process and the way bureaucracies, courts, legislatures, and interest groups function so they can introduce and promote their ideas in different institutional arenas (Schneider and Ingram, 1990). They seek out the most favorable venues for their ideas to give them the most leverage for change (Baumgartner and Jones, 1991; Schneider and Ingram, 1990). They develop and choose particular strategies that assist them in building support for their innovative ideas, including changes in institutional rules and norms to further their cause (Baumgartner and Jones, 1991). They try, whenever possible, to avoid opposition. But when that is not possible, they develop strategies and tactics to overcome resistance, including active participation by the media (Gifford, Horan, and White, 1992). They build coalitions, drawing support from elites who are effective in persuading others to participate (Baumgartner and Jones, 1991). And they select tools designed to induce policy-relevant behavior (Salamon, 1989).

"Policy entrepreneurs also tend to operate in teams or groups in order to better support and coordinate the complex activities involved in radical change."

Conducting a fine-grain analysis of six policy entrepreneurs, Roberts and King (1996) found that policy entrepreneurs operate in all policy phases, from policy initiation through policy implementation and evaluation. Their direct and long-lasting involvement enables them to protect and shepherd their innovative ideas all the way through the policy process, leaving less to chance in the hands of legislators, administrators, implementors, and evaluators.

Policy entrepreneurs also tend to operate in teams or groups in order to better support and coordinate the complex activities involved in radical change. Their logic is as follows. Since radical ideas deviate from existing practice, the more radical the idea, the more resistance is likely to be engendered, and the more resistance, the greater the need for collective entrepreneurship to protect the fledgling ideas and to overcome the opposition. Such a collectivity also needs to learn how to work together as a team and to attract resources in their press for radical change. Creative ways to finance and support the team's change efforts prompts them to develop an ecology of organizational support to sustain their entrepreneurial ventures over time. In pursuing these ventures, they must be careful to attract grassroots support, not just elites, in the pursuit of radical change.

Figure 2 ("Activity Structure of Policy Entrepreneurs") identifies the activity structure of six policy entrepreneurs uncovered in this longitudinal study of radical policy change (Roberts and King, 1996). "Creative and intellectual activities" are an important point of departure for policy entrepreneurship. Policy entrepreneurs generate new ideas and frame policy issues in such a way to demonstrate how their new ideas are the best solution to current policy problems and how they stack up against competing alternatives. They can invent these new ideas de novo or they can borrow or adapt them from other policy domains and settings. Once identified, the new ideas have to be disseminated in whatever form is appropriate (e.g., books, articles, conversations, speeches, news coverage) to reach the broadest audience. Attracting support among politicians and various elites often requires a good showing in opinion polls, and convincing the public requires

Creative and Intellectual Activities

Generate ideas
- Invent new policy ideas
- Apply models and ideas from other policy domains

Define policy problem and select solution
- Define performance gap
- Identify preferred solution alternative

Disseminate Ideas

Strategic Activities

Formulate grand strategy and vision
Evolve political strategy
Develop heuristics for action

Mobilization and Execution Activities

Establish demonstration projects
Collaborate with high-profile individuals and elite groups
Cultivate bureaucratic insiders and advocates
Enlist support of elected officials
Form lobby groups and coordinate efforts
Cultivate media attention and support

Administrative and Evaluative Activities

Facilitate program administration
Participate in program evaluation

Figure 2. Activity Structure of Policy Entrepreneurs

countless hours of work to get the message out and have it accepted.

Strategic activities are very important for policy entrepreneurs, first to formulate what their ultimate vision for radical change is, and second to develop strategies and tactics to deal with changing political realities. Unless the radical change agents are very clear about what they want, it is too easy to get deflected an pushed off course by others' goals and objectives. Political strategies and tactics are essential too because opposition is expected to run high, and countering it requires careful planning on how to deflect attacks likely to come their way. Developing heuristics for action are also important to guide policy entrepreneurs through the daily battles and to help them cope with the disappointments and reversals that are the natural consequence of pursuing radical change. The change heuristics developed by a team of six policy entrepreneurs are listed in Figure 3 below ("Change Heuristics That Have Stood the Test of Time"). They evolved these heuristics over years of experience in working toward radical change in different policy domains.

In addition to these heuristics, the policy entrepreneurs were keen observers of other radical change processes. They followed the events in New Zealand with great interest, where radical change has been under way since 1984. One policy entrepreneur provided a *Wall Street Journal* article titled "The Politics of Successful

1. Know where you want to end up and don't lose sight of where you are headed.
2. Don't play the "Washington game" by trading away the fundamental elements of the plan. Compromise may yield bad policy: Say "no" rather than give up the fundamentals of what you really want.
3. Wait for the "background conditions" (political context) to change, thus necessitating the kind of change that you want.
4. Mature bureaucracies like education rarely initiate meaningful change from within, so outside pressure is needed to force them to respond.
5. Change never comes through consensus. Get the key leadership to back your ideas and the "pack will rush to follow."
6. Money is needed to make change....Get the elites involved.
7. Stay with issues where you have the advantage.
8. Keep the establishment (education in this case) talking about change and structural issues, and you'll change some minds.
9. Destabilize the opposition by co-opting one of the establishment groups.
10. Be willing to be bold.

Figure 3. Change Heuristics That Have Stood the Test of Time

Structural Reform" (Douglas, 1990, p. A20) to illustrate the similarity between their change heuristics and those of the radical reformers in New Zealand. The purpose of the article, written by New Zealand's former finance minister (1984–1988), was to challenge assumptions people had of radical change. We highlight some

1. Structural reform (radical change) requires quality people. Good government in democratic countries needs politicians who can "get their minds around complex issues and have the guts to adopt policies" that result in real reform.
2. Define objectives clearly and implement reforms quickly. Speed is essential. If you move too slowing the consensus supporting reforms will likely collapse before results become evident. "It is uncertainty, not speed, that endangers structural reform programs."
3. Package reforms in "large bundles." Real reform is systems reform, not an unrelated "collection of bits and pieces." It is important to see linkages among system parts and use them to enhance all action.
4. Keep the momentum going and do not stop until you have completed the total effort. You are vulnerable to attack when challenging vested interests, but a rapidly moving target is much harder for opponents to hit. Stay in front to lead the debate and remove privileges evenhandedly to reduce opposition.
5. Maintain confidence and credibility through consistency of policy and communications. Avoid *ad hoc* decisions and do not waiver from your objectives. "People are unable to cooperate with real reform unless they know where they are going." When feasible, spell out intentions in advance. "Successful structural reform (radical change) is not possible until you trust, respect, and inform the electors." Tell people and keep telling them what the problem is, how it surfaced, what damage it is doing, what the objective is, how you will achieve the objective, what the costs and benefits will be, and why your approach is better than other options.
6. "Don't blink; public confidence rests on your composure." Structural reform (radical change) demands major changes in attitudes and beliefs. It causes real concern and discomfort. People will be "hypersensitive to any signs of similar anxiety" in those responsible for reforms. If people do not understand the argument, they will judge its merits on their assessment of your mental and emotional state.
7. When the pressure becomes extreme and there is temptation to accept an easy *ad hoc* compromise, remember why you are in politics. In a democracy, holding power forever is not the point. Best use the time to do something worthwhile. Genuine reform, without compromise, achieves greater gains than other approaches to decision making.

Source: Douglas, 1990.

Figure 4. Radical Change Heuristics From New Zealand

of the major points in Figure 4 ("Radical Change Heuristics from New Zealand).

Mobilization and execution activities expand the entrepreneurial repertoire beyond thinking and strategizing to actual doing. This comprehensive list of their activities opens up a whole range of options that can be considered by others. First, demonstration projects that test new ideas on a limited basis can provide some evidence that the radical ideas will work as predicted. Since evidence to support policy entrepreneurs' claims are often limited (radical change by definition has not been experienced before and finding evidence to support its merits is difficult), these demonstration projects, if successful, can lend some credence to their ideas. Yet demonstration projects cost money, which many policy entrepreneurs, operating on a limited budget, do not have. By necessity, they have to turn to others who do have the resources, usually elite groups, foundations, and think tanks that specialize in policy ideas and change. In the instance of the six entrepreneurs, they established a 501© (3) nonprofit corporation to serve as the fiscal agent for those foundations and associations who wished to support their ideas. A total of $1.2 million was eventually collected and funneled through the nonprofit, including a foundation grant to support one policy entrepreneur's research.

"Mobilization and execution activities expand the entrepreneurial repertoire beyond thinking and strategizing to actual doing."

To gain even greater credibility for their ideas, policy entrepreneurs often work with and through other organizations, especially those with high visibility and prestige within the larger community. Their linkages to high-profile organizations are particularly useful when these organizations can be influenced to issue position papers supportive of the policy entrepreneurs' views, as was the case in Minnesota with the reports from the Minnesota Business Partnership and the Citizens League.

Policy entrepreneurs also have to be careful to cultivate people who are policy system "insiders," especially those in government bureaus. To undertake radical change requires institutional memory and domain knowledge, insights that often only come from insiders who know the details of legislative history, preferences among the players, and how issues evolve and develop over time. The policy entrepreneurs in Minnesota credited a key insider whose advice at critical junctions made the difference in moving the ideas forward through the legislative process. Elected public officials need to be added to the policy entrepreneurs' network of contacts and supporters as well. Radical change does not occur without their sponsorship. Politicians play their part by moving ideas beyond the discussions among policy intellectuals and specialists and onto the agenda for legislative and execution action. Their careful cultivation and eventual championship is the sine quo non of the radical change process. Without Governor Perpich's active support in Minnesota, for example, public school choice most likely would still be a topic limited to policy debates rather than law to be implemented and evaluated.

Lobby groups also have a role to play. They demonstrate a visible and broadened base of support for the radical ideas. As

an added bonus, members can work to keep attention focused on the ideas and provide supporters to do the legwork (leafleting, testifying at hearings, preparing briefing notes and speeches, writing letters to the editor, and meeting with legislators. In the case of the six policy entrepreneurs, they not only attracted other lobby groups to support their cause, but they built their own lobby group that, by all accounts, was very effective during legislative sessions. Press coverage for all of these activities is also a must. Keeping the radical ideas before a public often distracted by the latest crisis and scandal requires a sophisticated understanding of the news business and a dedication to keeping reporters and their editors intrigued by the radical ideas and their implications for the general public. Coverage does not happen automatically, at least in any consistent way. It too must be managed.

Finally, influencing radical policy change requires effort beyond policy formulation. Without regard for the administration of radical policies—their implementation and evaluation—ideas embodied in the legislation are particularly vulnerable to bureaus that translate the laws into practice. The danger here is that bureaus, operating from difference frames of reference and beliefs, may well view the new ideas that initiate system-wide transformation as too disruptive of their current operations. They well may work to water down the changes or to resist them altogether, making implementation problematic. Alliances and advance planning with administrators and evaluators can anticipate some this resistance and work to overcome it, as the Minnesota policy entrepreneurs found. Well connected with the commissioner of educator and evaluation specialists, they were able to provide administrative and evaluative support to the Department of Education as it prepared to implement and evaluate choice in the public systems throughout the state. Their vigilance during the last two phases of the change process gave the radical ideas a fair hearing and kept the ideas from being subverted by school districts that were not enthusiastic about the new legislation.

"Radical change is defined as the transformation of a system in a relatively short period of time."

IMPLICATIONS

Radical change is defined as the transformation of a system in a relatively short period of time. System transformations can occur by chance, by consensus, by learning, and by entrepreneurial design. Thus far we have focused on radical change or system transformation by entrepreneurial design and highlighted some of the major activities that enable policy entrepreneurs to be successful. Having introduced this conceptual framework, now let's turn to some specific implications for acquisition reform.

When considering radical changes in acquisition, we first need to define the system. Is acquisition considered to be the system or is acquisition a subsystem embedded in a larger system called the "defense system"? The distinction is an important one. It means the difference between considering radical change in acquisition policy as an element transformation or a system transformation. Element

transformations are very difficult to pursue successfully if the larger system in which they are embedded are not fully supportive or compatible, especially if the element is tightly linked to the larger system. In the case of acquisition, a good argument can be made that it is a critical element within the larger defense system. Decoupling it from other important system elements such as doctrine, structure, and technology might be difficult given the centrality of acquisition to the Defense Mission. If that situation obtains, then the pursuit of radical change in acquisition without consideration of the larger system with which it must interface would doom the effort to failure or at best limit its impact.

"...the pursuit of radical change in acquisition without consideration of the larger system with which it must interface would doom the effort to failure or at best limit its impact."

To illustrate the point, let us assume that a policy has been put in place to empower program managers and program executive officers (PMs/PEOs) and enable them to change and streamline the acquisition process (e.g., depend on stable funding, adopt commercial practices, take risks), or to empower Contracting Officers (KOs) to relax acquisition regulations for greater efficiency. Following the above argument that considers acquisition tightly linked to other elements within the defense system, we would understand that PM/PEO dependence on stable funding is restricted because Congress controls defense funding, and program funding is inextricably tied to the PPBS (Planning, Programming, and Budgeting System). Adopting commercial practices is also constrained because industry would be required to behave as a "market," and this raises questions about the role of profit and the purpose of the defense system. Relaxation of acquisition regulations for KOs is also limited. Congressional authorization is required in many cases (executive delegation in all), and some key questions regarding control would have to be addressed: Under what circumstances can regulations be relaxed? For all KOs? For all acquisitions, from paper clips to aircraft carriers? And in a deregulated process, how can fairness across defense acquisitions be ensured?

Thus, acquisition policies are not independent elements to be transformed. In these instances, radically changing acquisition policy and using PMs, PEOs, and KOs as agents of change would require us to focus not only on acquisition but also on all the other elements within the larger defense system that would have to be compatible and mutually supportive of the people who were to champion and implement the changes. In other words, defense system transformation, not just acquisition transformation, would be the goal. Fortunately, recent reform initiatives (e.g., Secretary Cohen's Defense Reform Initiative) acknowledge the importance of taking a system's perspective and have announced a more comprehensive approach to change.

Another implication for acquisition reform concerns people who will function in the role of policy entrepreneur. Thanks to a growing body of research within this country and throughout the world (Douglas, 1990; Roberts and King, 1996; Eggers, 1997), we have a greater understanding of the strategies and tactics that successful radical change agents employ.

But within the acquisition or the defense system, whom do we see functioning in this capacity? Is it reasonable to expect radical policy change from PMs and PEOs who are central players within the acquisition system?

Research to date suggests that radical policy change is not initiated from system insiders. As many have noted, in the press for radical change, it is too easy for radical ideas to die on the inside (Roberts and King, 1996, p. 178). Insiders have the advantage of system knowledge, but they are usually limited and confined by existing organizational responsibilities and roles. Their daily organizational routines often drive out the time and activities needed to cultivate and develop radical ideas. Thus, the best vantage point for pursuing radical change is outside the target system. Outsiders often have more freedom to focus their attention and their energy. Their organizational detachment enables them to pay allegiance to the radical idea and not to any institution or its supporting structure. Better to be on the outside cultivating ties with well-placed insiders than it is to be on the inside suffering from restrictions imposed by bureaucratic constraints (Roberts and King, 1996).

Other studies support this preference for outsider status. Entrepreneurs in government in nonleadership positions as well as those in appointed leadership positions tend to be incrementalists (Levin and Sanger, 1994; Sanger and Levin, 1992). Their approach has been described as evolutionary tinkering. They combine old and familiar things in new ways, but do not offer fundamental breakthroughs. Most often, their innovative ideas develop through trial and error and evolve as adaptations to existing practice. Using the conceptual framework introduced above, they engage in element adaptation rather than element or system transformation.

We find evidence of element adaptation and incrementalism in the Office of the Deputy Under Secretary of Defense (Acquisition and Technology) (OUSD [A&T]). While the OUSD (A&T) is a relatively high-level position in terms of grade (ES-xx) and is charged with leading acquisition reform, the incumbent arguably has limited purview and authority. The use of credit cards for purchasing, and the emphasis of electronic commerce/electronic data interchange (EC/EDI), two reforms sponsored by the Deputy Under Secretary, serve as an example. Although each policy represents positive change, neither is considered a fundamental breakthrough. Both innovations have been used in the industry sector for two decades and neither affects the larger defense system as a whole.

"Research to date suggests that radical policy change is not initiated from system insiders."

Appointed executives tend to view their roles as limited by the legislature, which sets broad directions and makes choices about fundamental issues, new expenditures, and major policy changes. As one summarized, "For what it's worth, I think major new policy initiatives have to come from elected officials. I mean staff can have ideas, maybe bounce and buzz off them. But, ultimately, if you're going to affect large segments of your public, either in offering a new service or taking something away that has been there before...that's the legislature's call" (Zegans, 1992, p. 149).

Thus, if this initial research and its logic holds, radical changes in acquisition

policy would mostly likely be launched by outsiders to the acquisition system, even by outsiders to the defense system. Policy entrepreneurs have to be unencumbered by the status quo and be willing to take risks to change the whole system (Roberts and King, 1996). Returning to the above example, we would not expect the OUSD (A&T) or PMs and PEOs to initiate element or system-level transformations. As insiders, they are more likely to be incrementalists far more interested in tinkering around the edges of current policy.

So the question still remains: How does one launch radical reform of acquisition policy if acquisition is tightly linked to other defense system elements and cannot be treated as a separate entity, and insiders are likely to opt for incremental adaptations rather than element or system transformation? The answer, drawn from this conceptual framework, suggests that radical change has to be pursued from the perspective of the defense system, and it has to be led by policy entrepreneur outsiders whose allegiance is to the system and its integrity rather than to any system part or element. Finding those individuals and unleashing their potential will become the next important step on the way to radical reform. Their active involvement does not guarantee success; we have learned that they are one among many factors at play in the pursuit of radical policy change (Roberts and King, 1996). But policy entrepreneurs can and do make a difference. Reform springs from their initiative and drive. The process of radical change cannot begin without them.

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LEADERSHIP STYLES FOR THE FIVE STAGES OF RADICAL CHANGE

Dr. Kathleen K. Reardon, Dr. Kevin J. Reardon, and Dr. Alan J. Rowe

Leadership experts agree that a key challenge facing leaders now and in the future is responsiveness to radical change. This article continues prior work on radical change with theory and research on leadership style. The result is a model of radical change describing the leadership styles best suited to the successful implementation of each stage in the change process. Using the Leadership Style Inventory, leaders can determine which stages of radical change they are equipped to handle. The article explores how individual and group leadership style limitations can be dealt with to ensure radical change success.

The key component of successful leadership now and in the next century is proactive and effective responsiveness to change. Experts agree that successful leaders must be flexible and capable of adapting to new conditions, open to novel alternatives, and willing to take greater risks (Kotter, 1990; O'Toole, 1996). Too often leaders and managers address technical dimensions of change but fail to consider what it takes at each stage for leaders to actually carry out that change (Heifetz and Laurie, 1997a; Rowe and Mason, 1987; Rowe and Boulgarides, 1992).

Leaders who can do these things are referred to as Strategic Leaders (Reardon and Rowe, 1998). Such leaders recognize that most work now involves integration rather than fractionation of diverse interests and skills. Multiple styles of leadership are needed to effectively implement most forms of organizational change. Strategic leaders accept that they cannot have all the answers and they take steps to obtain information that effectively guides their choices. These leaders rely heavily on communication and persuasion with employees to advance their enlightened strategies. When compared to popular models of leaders of the past, strategic leaders are far more inclined to be information seekers than information distributors.

Figure 1 depicts the models of leadership from the early 1900s to today. In the 1900s, leadership was equated with those individuals who did "great" things. These

leaders had a "can do" attitude based on experience and determination. They used their authority to "command" others. By the 1950s, attention shifted to determining leader traits and how they fit the situations in which they function. In the early eighties, another change took place. This time the emphasis was on the "visionary" leader. These leaders inspired others with insights and shared authority. Today's leaders, confronted with explosive change, need to be "strategic leaders": sufficiently versatile to recognize the need for change, to seek input for developing creative strategies for change, and to inspire others to adopt those strategies.

According to Max DePree, author of *Leadership Is an Art,* leaders are vulnerable in their day-to-day-jobs. This vulnerability of leaders is currently exacerbated by the information superhighway affording access to extraordinary amounts of information. Leaders are confronted with far too many choices, as predicted by Alvin Toffler's 1980 forecast. He warned that this would inhibit action, result in greater anxiety and lead to feelings of exhaustion. Today's leaders also work with employees who are more diverse than those of their predecessors and customers and subsidiaries spread worldwide. Under such conditions, no single leader can possibly have all the answers or all of the styles required to accomplish the myriad tasks confronting him or her each day.

To effectively respond to the current chaotic environment, leaders must recognize their own strengths and weaknesses. They must understand the extent to which their leadership styles are suited to the demands they face and consider the types of people they need at their side to complement their styles. This is particularly important when organizations undergo

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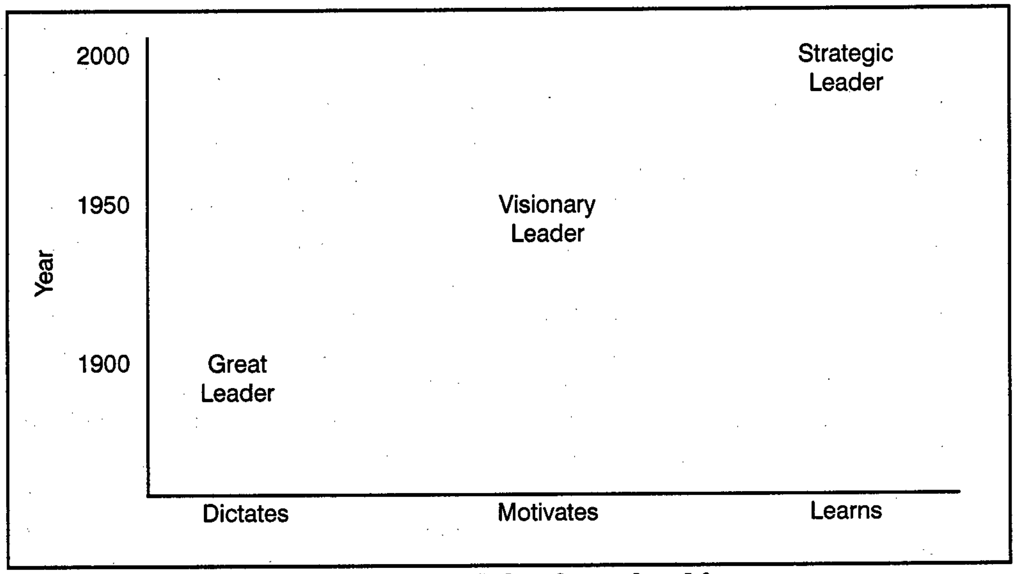

Figure 1. Models of Leadership

radical change. This article addresses the styles of leadership needed to accomplish organizational change and addresses the question: Can any single leader possess the styles needed to lead at every point in the change process?

Explanation of Leadership Styles

The leadership styles shown in Figure 2 were derived from work on the Leadership Style Inventory (LSI) developed by Rowe, Reardon, and Bennis (1995). The inventory identifies differences in style used by leaders that are based on the following two questions: How adaptive are leaders when dealing with the issues they face? How do leaders communicate with, persuade, and energize employees in the process of change?

The LSI identifies four basic styles: commanding, logical, inspirational, and supportive. One of its major strengths is that it also describes combinations of the basic styles called "patterns." These patterns help to describe the complexity behind leader behavior and competence for radical change.

The *commanding* style focuses on performance and has a short-term goal orientation. Commanders are highly productive and results oriented. They can be very effective when goal achievement is the primary focus. They learn better by their own successes and failures than by input from others.

The *logical* style pertains to leaders who insist on covering all alternatives. They have long-term goals, use analysis and questioning, and learn by reasoning things through. They are particularly effective when the goal is strategy development.

The *inspirational* style is characteristic of those who are able to develop meaningful visions of the future by focusing on radically new ideas; they learn

Leader style	Focuses on	Persuades by	Makes changes	Learns by
Commanding	Results	Directing	Rapidly	Doing
Logical	Innovation	Explaining	Carefully	Studying
Inspirational	Opportunities	Creating trust	Radically	Questioning
Supportive	Facilitating work	Involvement	Slowly	Listening

Figure 2. Leadership Styles (LSI)

by experimentation. They show a high level of concern for assuring cohesiveness of members of the organization and encouraging others to follow the vision. They are inquisitive, curious, and satisfied by finding radically new solutions.

Those leaders who are more concerned with consensus score high in the *supportive* dimension. They emphasize openness and operate more as facilitators than directors. They learn by observing outcomes and how others react to their decisions.

Most leaders do not possess a single style, but a combination. These combinations indicate which styles leaders are predisposed to use. Inventory scores indicate leader style predispositions.[1] A summary of how each style influences behavior in critical areas of leadership is discussed in Figure 2 (Rowe, Reardon, and Bennis, 1995).

American business executives tend to score high on the commanding style and low on supportive. Research using the LSI provides the following means for American executives: commanding, 86; logical, 80; inspirational, 81; supportive, 53. The means provide an indication of style predispositions. Style patterns, however, are not necessarily static. It is possible, even preferable, for leaders to develop the capacity to adapt their styles to the demands of situations, especially when their organizations are undergoing radical change.

A Case for Leader Versatility in the Change Process

The strongest case for versatility in leadership style comes from the recognition that change is not an event but an extended process. Each stage of that process benefits from different leadership orientations. Strategy researchers have proposed that change involves at least three stages: initiation, formulation, and implementation (Webb and Dawson, 1991; Pettigrew, 1987; Child and Smith, 1987, Rajagopalan and Spreitzer, 1994. Another model (Rowe and Mann, 1988) proposed four factors in the change process: Decision maker's

[1] LSI scores are derived by adding down the four columns of the inventory. The four derived scores (one for each style) total 300. Means are based on the inventories of hundreds of American executives in the Marshall School executive MBA program and those in businesses with which we've consulted.

style, organizational culture, employees' willingness to change, and acceptance of change based on a match among values, culture, and decision style.

John Kotter (1990) proposed that leading change requires: establishing direction, aligning people, and motivating and inspiring. Our model, depicted in Figure 3, draws upon Kotter's model but adds two stages described by Kotter but not specifically stated in his model: launching and maintaining.

While Kotter implies the existence of launching in the aligning stage of his model, we propose that separating it out is imperative to understanding the processes involved in radical change, especially that of leadership. Small or incremental changes often do not require a formal launch. They can be introduced in small doses with change hardly being noticed. Radical change, however, demands that people depart drastically from the *status quo* and often that they do so in a limited period of time. Launching takes the place of introducing change in dribs and drabs.

Our reasons for clearly articulating the existence of a maintenance phase comes from persuasion theory and practice. People resist change, especially radical change. Persuasion research indicates that choosing to comply, rather than being forced into it, leads to longer adherence to change. Radical change requires more than mere compliance. It requires private acceptance. This occurs when employees actually believe in the need for change and are therefore willing to relinquish old modes of working in favor of long-term new ones.

Achieving private acceptance is an across-phase process from planning the change through to maintaining it. Overlooking the maintenance phase is a significant oversight in any model of change. Private acceptance doesn't assure that a change will endure; it merely sets the stage for that result. Employees must be encouraged to continue the change even in the face of occasional obstacles. We emphasize maintenance, especially in a model of radical change, since perceived failures can send employees rushing back to prior, once-mastered ways of doing things.

The primary impetus for this paper is not so much to expand upon prior models of change, but to emphasize and develop an understanding of the role that the leadership style plays at every stage of that process. Leadership style and organizational change theory and research have existed for decades, but have rarely conjoined. The concept of the leader being suited to the task is found throughout leadership literature as far back as Plato. He argued that while it's appropriate to turn to a physician to solve medical problems, a philosopher-king is needed to resolve problems of public policy. Heifetz (1994) suggests that the same is true today within organizations. For what Heifetz describes as adaptive change, "authority must look beyond authoritative solutions" (p. 87). To do this requires flexibility in style within the organization. Launching radical change, for example, is a substantially different process than maintaining it. As such it requires a different leadership style orientation.

"People resist change, especially radical change."

To date, researchers and leadership experts have discussed the need for

leadership style flexibility in substantive change efforts, but they have not attempted to conjoin radical change phases with knowledge about leadership style. The linkages between change stages and leadership style types constitutes the breaking of new ground. The model is grounded in our study of leadership style and of organizations undergoing change efforts, several examples of which we share in later descriptions of each radical change phase.

As indicated in Figure 3, we propose that radical change requires considerable reliance on the inspirational style. It is imperative to four of the five stages of change. Unlike incremental change, radical change requires that leaders think creatively and take risks. These are the hallmarks of the inspirational style. There is no blueprint to follow in radical change. It is both new and a significant departure from prior modes of operating. To overcome the resistance to radical change described earlier, inspirational leaders are needed throughout the change process. In the planning phase, they provide creative input. They empower and involve followers in the enabling phase, inspire and energize them to adopt the change after it

Phase	Focuses	Style
Planning	Acquire information Creative ideas Strategy formulation	Logical/inspirational Inspirational Logical
Enabling	Explaining plan Convincing employees Empowering/involving Assisting	Logical Logical Inspirational/supportive Supportive
Launching	Implementing steps Meeting goals Getting results Assessing progress	Logical Commanding Commanding Logical
Catalyzing	Inspiring Energizing Assisting	Inspirational Inspirational Supportive
Maintaining	Overseeing progress Guiding Energizing Assisting	Logical Inspirational Inspirational Supportive

Figure 3. Senior Manager Leadership Styles for the Five Phases of Radical Change

has been launched and to maintain it despite obstacles. This is reminiscent of the description Hammer and Champy (1993) provide of the reengineering leader (p. 103):

> The leader's primary role is to act as a visionary and motivator. By fashioning and articulating a vision of the kind of organization that he or she wants to create, the leader invests everyone in the company with a purpose and a sense of mission. The leader must make clear to everyone that reengineering involves a serious effort that will be seen through to its end. From the leader's convictions and enthusiasm, the organization derives the spiritual energy that it needs to embark on a voyage into the unknown.

But inspirational leadership alone is not sufficient. Hammer and Champy agree here as well. "Urging people isn't enough," they argue. People react warily and cynically to executives insisting that the rules be broken and prior wisdom be defied unless a support system is in place so they can do these things. As Figure 3 depicts, radical change also requires the presence of logicals, supportives, and commander types—but not always working together at each point in the change process. Unlike the inspirational leader, who encourages the risks involved in radical change, logicals, supportives and to some extent commanders are need to provide a support system that enables everyone to go against the grain and stay there for the long-term.

Figure 3 was developed as a blueprint for assigning the most effective leader types to each phase of radical change, which we'll now discuss.

PLANNING

This stage involves charting the course for change. Here the emphasis is on creativity, garnering important information, identifying obstacles, considering alternatives, and selecting among them. As shown in Figure 3, the leadership styles best suited to this are the logical and the inspirational. The logical leader constantly seeks new information, identifies obstacles, generates alternatives, and considers pros and cons in the final selection. Inspirationals contribute to this process by encouraging employee input in the search for creative plans

> **"The logical leader constantly seeks new information, identifies obstacles, generates alternatives, and considers pros and cons in the final selection."**

To encourage people to provide information, Stanley Gault, CEO of Goodyear, decided to refer to all employees as "associates." It opened up lines of communication. Jack Welch, CEO of General Electric, attributes part of his success to opening up channels of communication with employees. "To create change, direct, personal, two-way communication is what seems to make the difference: exposing people to ideas from everywhere, judging ideas on their merits" (Tichy and Sherman, 1993).

Mort Myerson (1996), Chairman and CEO of Perot Systems, makes it clear to people that there are a whole lot of things he can't do. When they come to him looking for "the plan," he tells them he doesn't know the plan. "We're either going to figure out the company's future together or

we're not going to do it at all" (*Fast Company,* p. 10).

Myerson's approach fits the radical change model information gathering, employee involvement approach. Planning requires a learning approach to change. You can't empower people if you think you have all the answers. Mort Meyerson says he learned about leadership by opening himself up to doing so. "I told myself I was having the same experience as a caterpillar entering a cocoon. The caterpillar doesn't know that he'll come out as a butterfly. All he knows is that he's alone, it's dark, and it's a little scary." He realized while in that cocoon, "I don't have to have all the customer contacts. I don't have to make all the decisions. In fact, in the new world of business, it can't be me, it shouldn't be me, and my job is to prevent it from being me" (*Fast Company,* p. 10).

"The enabling stage not only prepares people for change, but also provides an opportunity for leaders to frame that change."

Research indicates that executives who spend long periods of time in the same jobs or industries develop limited perspectives. Their knowledge base is limited and so is their desire to expand upon it (Cyert and March, 1963; Tushman and Romanelli, 1985; Miller, 1991, Rajagopalan and Deepak, 1995). Their thinking becomes rigid, which in turn limits the strategies from which they might choose. The lesson here: If you're going to stay in a job for a long time, keep the information flowing.

Enabling

The focus in this phase is on explaining the plan to those who will be involved in the change effort, and convincing them that the direction chosen is not only best, but one that depends on their contributions. In this stage, enabling or empowering employees provides needed assistance in preparing to launch the change process.

The enabling stage not only prepares people for change, but also provides an opportunity for leaders to frame that change. Frames are schemata used to interpret events (Goffman, 1974). They can assist leaders in explaining to others how change efforts should be interpreted. Fairhurst and Sarr (1996) argue that "We assume a leadership role, indeed we become leaders, through our ability to decipher and communicate meaning out of complex and confusing situations" (p. 2). The way a leader frames a planned change influences whether potential followers see only constraints and roadblocks or opportunities and potential success.

This framing ability is at the heart of the distinction leadership expert Abraham Zaleznik (1977) made between managers and leaders. The former pay attention to how things are done, the latter pay attention to what events and decisions mean. Warren Bennis and Burt Nanus (1985) were describing framing when they wrote that leaders concern themselves with the organization's basic purpose and general direction and with articulating these ideas to others. When used effectively, frames create understanding—the basis for action—and make collective behavior possible by enabling belief in one view to prevail over others (Fairhurst and Sarr, 1996).

Three styles are particularly useful in the enabling stage. The logical style helps leaders develop frames to explain a change. The inspirational style facilitates

the process of frame development by encouraging open discussion. The supportive style provides employees with a sense that they will find help adjusting to the new change.

LAUNCHING

This is the stage in which the change effort commences. To launch effectively, leaders need to meet specified launch goals, achieve early results to demonstrate the value of the plan, and assess progress along the way. While this definition of the launch stage does not preclude occasional reliance on the inspirational or supportive styles, the emphasis is on practical concerns of getting under way and achieving goals. These are better accomplished by the commanding or logical style pattern. The logical style helps in the explanation of specified launch goals and the commanding style encourages a determination to achieve them.

One of the chief obstacles in this stage is resistance to change. A natural inclination, when confronted with naysayers and critics, is to strike back. Max Depree warns that "leaders don't inflict pain, they bear it." DePree argues that too many leaders see disagreement as an indication of rebellion. They prefer to surround themselves with loyal "lieutenants" who do not threaten their leadership.

But what if resistance is reframed? What if dissent is interpreted by leaders as potentially important information? The likely response is less defensive. If leaders have truly thought through the changes they propose, then they can be confident and comfortable with dissension. According to James O'Toole, author of *Leading Change,* "To lead effectively is a matter of clear thinking on the part of the leader. Leaders must be clear about their own beliefs, they must have thought through their assumptions about human nature, the role of the organization, the measurement of performance, and so on" (1996, p. 46). Essentially, if leaders have done their homework regarding proposed change, if they have logically thought through the pros and cons, as logicals do, then they will have the confidence to encourage contrary opinions and the wisdom to learn from them. Once they have entertained doubts and skeptics and responded effectively, their orientation can shift to directing people, in a nonauthoritarian manner, toward mutually defined goals.

"One of the chief obstacles in this [the launch] stage is resistance to change."

There are times when commands work extremely well. In an emergency somebody has to take charge. When tough budget decisions must be made or personnel problems call for quick action, the commanding style may be most appropriate. Leaders who use a commanding style are not necessarily bullies forcing their ideas upon others. They are, however, goal oriented and have a very good idea of how they want to reach it. Once the planning and enabling stages of change have been effectively conducted, the direction of change should be one that the leaders, with follower input, have worked together to define. At this point, someone or some group needs to point the way. This is when a results-oriented approach can be beneficial. It doesn't require completely closing down avenues of input, but it does require focusing on moving along the defined path.

CATALYZING

During this stage people, not plans and practices, are the paramount focus. They are the ones who will make or break the change effort. To be effective, people must feel that their efforts count. The people-oriented styles of inspirational and supportive leaders become important at this stage. The other two styles may assist in the process. An occasional commanding push to meet goals or a logical leader's explanation for taking a certain route may prove useful, but the greater emphasis in this stage is on involving and energizing people.

The inspirational style encourages people to expend energy and invest time in the change effort. Linda Wachner, CEO of Warnaco, says, "The biggest obstacle to change we encounter is keeping peoples' energy up." She asks, "Once they're dreaming the dream and they see it in return on their own equity, how do you continue keeping the energy up?" Her answer is to reward small successes along the way. She brings employees together to feel good about what they've done. It builds energy and momentum in people ("Leaders of Corporate Change," 1992).

"The inspirational style encourages people to expend energy and invest time in the change effort."

Another organization noted for its emphasis on encouraging innovation is 3M. Employees spend as much as 15 percent of their work time on projects of their own choosing. Up to $50,000 in grants is given to encourage inventions. William Molthight introduced the maxim at 3M that is still followed today: "Listen to anybody with an idea and encourage experimentation and doodling —if you put fences around people, you wind up with sheep."

Supportive leader behavior can offset the negative effects of stressful situations. It can be especially beneficial when tasks are psychologically or physically distressing (House, 1995). Since most change efforts foster uncertainty and some degree of distress, especially after the initial excitement has worn off, leaders can encourage continued investment in change efforts by being attuned and responsive to the concerns of those who follow them. Mentoring, guiding, counseling, coaching, providing helpful feedback, and empowering workers can keep change on track.

Boeing discovered the benefit of giving people the authority to make changes. Their traditional method for designing aircraft in the early 1990s was "surprisingly primitive" (*Fortune,* 1993). First, engineers designed the plane's shape and components, the blueprints went to manufacturing experts who planned the production and final assembly, and finally, the manufacturing plan went to tooling specialists who designed specialized production machinery. The phases were all in sequence, causing them to take a long time. The three groups had little contact, so tooling specialists often received blueprints for parts that couldn't be manufactured or ones that were too expensive to produce.

Boeing changed their primitive methods by having engineers, manufacturers, and tooling experts operate concurrently and together rather than in sequence and independently. Equally important, they eliminated expensive redesign work by freeing the teams of bureaucracy. The changed philosophy: "When the group

decides to alter the design of a major part, it has the authority to make the changes itself, rather than waiting months for approvals from higher-ups" ("Can Boeing Reinvent Itself?"1993, p. 18).

Edward Lawler, in his book *From The Ground Up (1996)*, argues that the popular job enrichment approach to keeping people interested is limited. Enriching the jobs of toll collectors, telephone sales representatives, reservation agents and others where duties are tied to repetitive customer contact or to technology is a daunting task. Lawler suggests a "new logic" in which people become involved in a variety of team types. Problem-solving teams can work on identified challenges, work teams can be assigned the task of getting work done, project teams can be formed to manufacture a particular product or deliver a service, overlay teams coordinate groups and individual activities and management teams exist to manage other teams and individuals solving integration issues. This multiple team approach offers a place for everyone in assuring that project and organizational change goals are met and can be especially successful if the right types of teams are chosen for the job and organization.

Such involvement is a promising means of catalyzing change efforts. If people are to remain energized, they need to feel that they aren't swimming like salmon upstream, that their ideas are welcome, and that they will receive the assistance they need to make their work more productive and rewarding.

MAINTAINING

This often overlooked stage of the change process requires overseeing, guiding people to continue their efforts and providing them with the motivation and assistance to do so. Here the style emphasis is once again on people. Persuasion becomes crucial.

Persuasion calls for an ability to listen well enough to know what matters to people. The ACE Model of Persuasion (Reardon, 1981; 1991) indicates that people are more likely to change if they see what's expected of them as *appropriate* given who they are and what they can do, *consistent* with their own self-image and goals, and *effective* in terms of bringing them the kinds of reward they value.

"Persuasion calls for an ability to listen well enough to know what matters to people."

The logical style is useful in identifying and reading the cues that enable leaders to communicate in ways that are relevant to people. If people don't see themselves as capable of stretching when the bar is raised, if they think it's inappropriate for them to do so or likely to lead to punishment rather than reward, they won't stretch. Leaders need to convince them that doing so is the appropriate, consistent, and effective thing to do.

According to Jack Welch, this means finding a way to engage the mind of every single employee. If you don't find a way to make every person feel more valuable, then you end up with wasted minds, uninvolved people, and a labor force that's angry or bored. Welch sees only one way to get more productivity from people: to get them involved ("Jack Welch's Lessons for Success," 1993). Persuasion is not something done to people but rather something done with them. So you have to

know what matters to them and use that, and a sense of ownership, to encourage their best work.

Change maintenance requires an ongoing emphasis on input and involvement. This is where the inspirational and supportive styles play a crucial role. If people feel that their ideas, once considered valuable, are being ignored, they will cease to take an interest in making change work. Often change is undermined by failure to involve people and assist them in maintaining it. According to leadership experts Ronald Heifetz and Donald Laurie (1997b), this may mean managing the rate of change, orienting people toward new roles and responsibilities, clarifying business realities and key values, and defining conflict as part of the process.

"[Strategic leaders] recognize the importance of people in the organization and concentrate on ways to challenge people and stretch their imaginations in forming and implementing strategies."

HOW VERSATILE CAN ONE LEADER BE?

Leaders who are versatile are identified as *strategic leaders*. They recognize the importance of people in the organization and concentrate on ways to challenge people and stretch their imaginations in forming and implementing strategies. They see visions as the product of ongoing conversations between them and the people who carry them out. They focus on and reward creativity and readily accept innovative solutions to problems. They value proactive thinking, avoid "reacting" to situations, and reject autocratic rigidity. Yet, when the path has been determined and people are "on board," this same leader gives direction and looks for results.

This is a tall order for a single leader. Consider, for example, Pfeffer's description of leader sensitivity. Pfeffer (1992) considers leader power the ability to influence followers. This inevitably calls for being able to understand them. He explains that this sensitivity to people "does not mean that one is necessarily going to act in their interests, in a friendly fashion, or on their behalf," but it does mean "understanding who they are, their position on the issues, and how best to communicate with and influence them" (p. 172).

Pfeffer argues that sensitivity to others requires "an almost clinical interest in the observation of behavior...not only self-awareness, but more important, awareness of others" (p. 173). These skills are not taught in most schools. Those courses that do exist are cursed with the derogatory "touchy-feely" label by educators and practitioners focused on what they consider "the hard facts." So, how do leaders, trained in traditional ways, come to understand themselves and others?

Complicating the issue further is the findings of gender researchers indicating that men are less inclined than women to engage in the sensitivity Pfeffer describes (Kanter, 1993; Reardon, 1995; Rosener, 1990). In fact, our research using the LSI shows that female first-year MBA students are significantly more *supportive* in their leadership style than their male peers. By the time they graduate, however, these same women have shifted their style in favor of the logical

style more consistent with the MBA curriculum.

A similar challenge faces leaders who are not inspirational leaders by nature. How do leaders suddenly take on the mind-set and actions of someone whose manner of articulation encourages people to follow their lead? The inspirational style occurs more frequently than any other in the five-stage model of radical change. It's possible to stretch oneself, work on framing and delivering ideas to make them more relevant and attractive to people. But acquiring an inspirational style is not a simple overnight task.

We are left with the conclusion that perhaps few, if any, people are capable of being leaders of every stage in the change process. For those who insist on having their hand in every effort, this can be disconcerting news. But from another vantage point, not leading every stage relieves leaders of having to be all things to all people and gives them the opportunity to step back and observe and consider the change process. Here again, Pfeffer offers an important insight. Rather than consider power to be in the hands of one person in all situations, he proposes (1992, p. 78) that: "An important source of power is the match between style, skill, and capabilities and what is required by the situation." Referring to observations of 304 laboratory research professionals asked to describe the source of influence in their organization, "the principal finding was that the type of person who was influential depended on the nature of the project." In technical service projects, with less task uncertainty, internal communication stars (those with many internal contacts) were most influential, while in applied research units, boundary spanners carried the most weight."

As an example in the military context, it is instructive to consider the leadership style aspects prominently displayed by three famous World War II generals in the U.S. Army. Although each was a consummate leader and undoubtedly capable of fulfilling a variety of roles, they were placed in highly responsible positions in which their individual leadership styles proved especially effective. Gen. George S. Patton, Jr., was a brilliant tactician, a student of military history, and one of the Army's most intellectual officers. His mission assignments often placed him in situations requiring a leadership style that could elicit immediate response to his tactical commands in the midst of grueling tank battles. Although some have argued that the intellectual in Patton might have preferred a "kinder, gentler" approach to motivating the desired results, there is no doubt that he was extremely successful as a *commanding* leader.

"We are left with the conclusion that perhaps few, if any, people are capable of being leaders of every stage in the change process."

By comparison, Gen. Dwight D. Eisenhower was responsible for organizing much of the Allied planning for the invasion of Europe and facilitating cooperation among diplomats and soldiers of many nations. He achieved great success by emphasizing his skills as an inspirational and supportive leader, even though he must have been sorely tempted at times to exercise directly his command authority and the commanding skills he so clearly exhibited during his rise to the top. Fortunately, Eisenhower recognized that persuasion

and team-building were the keys to success in his position.

A third soldier of great military and leadership skill was Gen. Omar N. Bradley. During a portion of the war effort, he found himself serving as a facilitator in support of Eisenhower, providing the logical explanations of policy matters and directives to other senior officers of U.S. and Allied forces. In that role, he persuaded by explaining the rationale for selected courses of action and was supportive of others as they expressed their concerns and reservations. General Bradley certainly demonstrated in a variety of critical situations during the war his command skills and his personal ability to inspire, but it is instructive to reflect on how he relied on his logical and supportive skills as one of Eisenhower's key facilitators.

"The TARDEC and general examples indicate that leadership is seldom a one-person job."

For acquisition professionals a useful example of adjusting one's style to the demands of the task is the change effort launched by the U.S. Tank-Automotive Research Development and Engineering Center (TARDEC), the nation's laboratory for advanced military automotive technology. In their effort to achieve global technological superiority in military ground vehicles and providing affordable military systems and the most commercial competitive products, TARDEC's 1988 management team headed by Ken Oscar recognized that commitment and personal involvement would be fundamental. They would need to put customers first. They realized, however, that this would require commitment on the part of their employees (associates). To assure the buy-in of their people, they placed air conditioning in the main building (the number one complaint) even though rules and regulations indicated the arsenal was too far north and the number of cooling days too few (an anti-commanding style move). Substantial renovation of 13 buildings was accomplished, costing more than $35 million. Innovation became a paramount feature in the TARDEC effort (inspirational orientation) as evidenced by a first-of-its-kind professional development program along with the establishment of TARDEC virtual university.

The phase approach to achieving their vision along with an openness to innovative ideas provided the foundation for the TARDEC change effort. It was only after they'd creatively established credibility with their own associates (aligning, enabling, and motivating) that TARDEC leaders were ready to launch their customer focus. They set up a marketing office to coordinate customer requirements, expectations, and feedback which goes to Center scientists and engineers. Their Fielded Vehicle Performance Data System (FVPDS) team of associates developed a sophisticated database which accesses 20 different vehicle logistics and performance tracking systems, enabling TARDEC to anticipate customer needs and provide quick responses (DoD, 1997).

The TARDEC and general examples indicate that leadership is seldom a one-person job. Of course, the buck has to stop somewhere, but in day-to-day change efforts, it's better to share responsibility and learn what needs to be done from the people who get it done. James O'Toole writes that "leaders fail when they have

an inappropriate attitude and philosophy about the relationship between themselves and their followers" (1996, p. 37). One of the most inappropriate attitudes is that the leader knows everything. O'Toole proposes that the best leaders always include people who are affected by change in the process of planning and making that change.

Awareness of one's leadership style is critical to being an effective leader of change. Although changing styles is difficult, awareness provides a basis for focusing on the style that best fits each stage of change. It helps leaders identify whether they are prepared to lead the entire change process or whether they might benefit from allowing others to do so with them.

Research shows that some groups do prefer certain style types. Comparing female and male MBAs was mentioned earlier. In another study, international MBA students scored higher on the supportive style and lower on the commanding style than the typical executive MBA student from the United States. Asian and Irish MBA students score higher on supportive than comparable U.S. MBAs. A group of presidential fellows at the University of Southern California, who were chosen by their respective schools for their potential as future leaders, had significantly higher scores in both inspirational and supportive styles than the population as a whole.

To stretch their leadership styles, leaders need to be aware of their predispositions. The LSI provides that information. By linking the LSI with the Five-stage Radical Change Model, leaders can see where their own and their peoples' strengths and challenges lie. Knowing what you're best suited for and what might be more effectively led by others is critical to achieving success in today's environment of radical change.

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TEAM-BASED REDESIGN AS A LARGE-SCALE CHANGE

APPLYING THEORY TO THE IMPLEMENTATION OF INTEGRATED PRODUCT TEAMS

Susan Page Hocevar and Walter E. Owen

The implementation of integrated product and process development through integrated product teams represents a large-scale organizational change. This article draws from existing theory and research related to both large-scale change and team-based organization design to identify critical issues that must be explicitly managed to achieve the desired optimal outcomes of IPPD and IPTs.

The words of Secretary of Defense William Perry (1995) were "I am directing a fundamental change," as he endorsed the implementation of integrated product and process development (IPPD) through integrated product teams (IPTs). This executive mandate recognizes the potential value of cross-functional integration of complex processes to reduce cycle time, improve quality, and reduce costs in acquiring goods and services required by the Department of Defense (DoD). Achieving these performance outcomes is required by both budgetary constraints and citizen mandate.

The language of "fundamental change" also reflects an appreciation of the challenge of effectively implementing the IPPD concept. This change requires attention to organizational level factors that include structure, culture, and decision processes; group level factors related to interpersonal dynamics, team building, and intergroup coordination; and individual factors of motivation, conflict management, and empowerment.

A substantial body of management research has found that organizations often do not meet the anticipated benefits of teams because implementation did not

reflect a comprehensive analysis of the requirements of designing a team-based organization. The purpose of this article is to draw from existing theory and research related to both large-scale change and team-based organization design to identify critical issues that must be explicitly managed to achieve the desired optimal outcomes of IPPD.

What is Large-Scale Change?

Through the 1980s there was evidence of an increasing demand on organizations to change on a large scale in order to gain or retain a competitive position. This impetus for change resulted largely from advancing technology, increasing global competition, and increasing professionalization of the workforce. There is also evidence of the pervasiveness of large-scale change in the popular management press articulations of "reengineering" (e.g., Hammer & Champy, 1993) and in the public sector initiatives for "reinventing government" (e.g., Gore, 1993). The premise of these change initiatives is that our traditional public and private organizations that have historically emphasized efficiency, predictability, and top-down control are no longer appropriate for the changing and competing requirements for organizational performance.

While there has been a substantial history of research and theory on organizational change in the management literature, the distinctive characteristics of "large-scale organization change" began to be explicitly discussed in the mid-1980s. Large-scale change redefines fundamental aspects of an organization including both design and process (Ledford, Mohrman, Mohrman, and Lawler, 1989). The comprehensive approach to large-scale change recognizes that organizations are complex open systems and thus requires that change must simultaneously address structure, technology, human resources, and tasks (e.g., Galbraith, 1989; Nadler, 1981). Change in design implies new ways in which work is divided and

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coordination and integration are achieved. It also requires that formal support systems such as information technology, financial, and human resource systems be realigned to fit the change in strategy and structure. Change in processes can include substantial modifications in communication, decision processes, and participation strategies. The process aspects incorporate informal mechanisms that provide flexibility to the more formal structural design aspects.

Another distinguishing feature of large-scale change is its scope. Such changes reach broadly across organizational work units and across multiple systems and processes. But breadth of change is not the only dimension of scope. Large-scale change also requires substantial depth that goes beyond change in structures and systems and addresses required changes in mission definition, strategy, culture, values, and behavioral norms. While the challenge of changing organizational structures is significant, changing the deeper values, beliefs, and norms is both difficult and necessary to accomplishment of the goals of large-scale change. It is possible for organizations to change reporting relationships, create teams, revise operational procedures and accountabilities, and still have day-to-day work being done largely in the "same old way." Fundamental change at the level of values, norms, and behaviors is essential to large-scale change.

IPPD and IPT as Large-Scale Change

Here we assert that the adoption of a team-based organization for implementing IPPD (see Figure 1) meets the definition of large-scale change in the character of an organization's design, processes, and culture. This figure illustrates the open systems concept that is at the heart of large-scale change (Galbraith, 1989; Nadler, 1981). The IPPD process recognizes the comprehensive requirement to modify and align team structures, analytic and decision tools, and processes to achieve optimal performance as defined by customer criteria.

The implementation of team-based design is specifically illustrated by the Naval Aviation Systems Team (TEAM) Integrated Program Team Manual: Update (NAVAIR, 1996). This manual presents the structural realignment to IPTs within the Naval Air Systems Command (NAVAIR—the Competency Aligned Organization (CAO). The CAO defines the human resource and process capabilities of core competency areas to support program teams. It also defines the team leadership and membership responsibilities for functional competencies and program teams within the CAO structure. The manual also describes new process requirements that include the chartering of IPTs, operational processes, conflict management, personnel evaluations, communications, and financial management.

The F/A–18 Hornet Program Office is prototyping the conversion toward IPPD/IPT realignment with the Naval Aviation Systems Team. The F/A–18 Program Operating Guide (POG) (PMA–265, 1996) describes and outlines IPT implementation procedures. According to the POG:

> The two main tenets of our Naval Aviation System Team (TEAM) are that we are a competency-aligned organization and

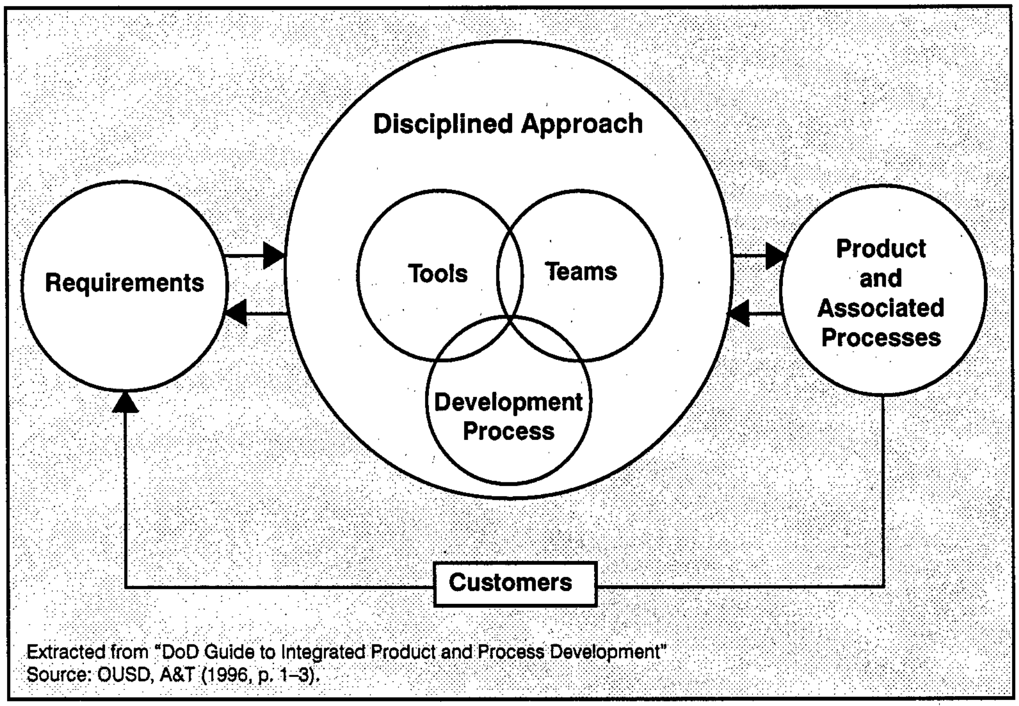

Figure 1. Generic IPPS Iterative Process

> that we accomplish work on teams. Over the past two years a tremendous amount of energy has been focused on the establishment and development of the competency side of the TEAM. Last year the Hornet Program was assigned the lead in focusing a similar level of intensity in implementing the IPT side of the CAO/IPT equation (PMA-265, 1996, p. i).

The assumption of this article is that in order for IPPD to be successful, the planning and implementation of IPTs must be treated as a large-scale change effort. Below we will expand the theoretical framework for analyzing the DoD implementation of the IPPD/IPT concept. DoD IPPD/IPT implementation guidelines and procedures within the TEAM and F/A–18 Hornet Program Team are used in this paper to specifically illustrate aspects of the theoretical propositions.

TEAM-BASED REDESIGN: A LARGE-SCALE ORGANIZATIONAL CHANGE

This section emphasizes the effective use of teams as a comprehensive organization design strategy. This emphasis is congruent with IPPD/IPT as a large-scale change initiative. Successful team-based redesign requires large-scale change. Restructuring an organization around teams and cross-functional processes reflects an approach to change that is significantly more comprehensive than change initiatives that focus solely on team building and group and interpersonal dynamics. In fact, while this latter emphasis has been

dominant in many organizations as they implement teams, the research finds that attention to organizational context has the most significant impact on overall team effectiveness (Cohen, 1994; Cohen, Ledford, and Spreitzer, 1996).

The large-scale change literature would argue for expanding the definition of organizational context to include not only system support such as information and training but also organizational culture and processes such as rewards and inter-team integration. In the sections to follow, three defining characteristics of large-scale change are used to present the current research and theory on team-based organization design and the implications to IPT effectiveness. The three domains of change we address are structure, process, and culture (Figure 2). Changes in structure require analysis of tasks and interdependencies and a determination of appropriate integration mechanisms; changes in processes address redefinition of roles and aligning support systems (e.g., information, performance management); and changes in culture are manifest in behavioral norms and informal reward systems.

Structure	Process	Culture
• **Task Analysis** - Nonroutine task interdependence • **Composition** - Below 20 members - Self contained • **Team Integration** - Strategy - Liaison roles - Overlapping - Integrative management teams	• **Control Systems** - Clear objectives - Measurement - Reward systems - Self management • **Performance Management** - Team evaluations - Informal feedback: multiple perspectives - Appropriate input to formal ratings - Peer input • **Clear Charter** - Member roles - Team vs. work group • **Leadership** - Leader vs. manager - Shared leadership	• **Empowerment** - Impact - Competence - Meaningfulness - Choice • **Managerial Norms** - Openness - Cooperation - Trust - Delegation - Informal reward - Resource support

Figure 2. Team-Based Design as Large-Scale Change: Considerations for Implementation

STRUCTURAL CHANGES IN TEAM-BASED DESIGN

Teams provide a mechanism to increase flexibility of performance in the context of increasing environmental turbulence. This flexibility is achieved due to the improved cross-functional coordination and decision making; the dedication to process improvement; and the improved motivation derived from the job enrichment offered by work that is organized around teams. However, such teams should not be seen as the panacea for all requirements for coordination, flexibility, and increased motivation. In fact, the implementation of IPPD is product and process dependent and must be tailored to a particular organization's needs and requirements (OUSD, A&T, 1996).

"Identifiable bottlenecks in decision making due to conflicting functional perspectives often signal work domains where team structure is appropriate."

Teams represent a high-cost organization design strategy and the decision of whether and how to structure teams should be informed by three types of analysis (Mohrman, Cohen, and Mohrman, 1995). First, processes must be analyzed to determine which sets of activities have to be integrated with each other to provide increased value to the customer. Second, it should be determined if teams are the appropriate coordination mechanism. Teams are appropriate for coordination of nonroutine interdependencies. However, if cross-functional interdependencies are standard and predictable, teams are not necessary to achieve integration. Finally, explicit analysis of decision processes can provide important guidance as to where teams should be established.

The F/A–18 program illustrates the use of IPTs to address cross-functional coordination requirements as defined by specific business or product lines. The F/A–18 POG describes the program team structure as follows (PMA- 265, 1996, p. 3):

> The F/A–18 Program Team is structured along the line of product-focused, multidisciplinary Integrated Program Teams (IPTs). There are three major (Level I) IPTs in our program, reflecting our three prime business areas...Each of these IPTs consists of product-focused teams known as Integrated Product Teams.

These IPTs represent teams that bring together cross-functional tasks with high interdependence toward a common product (e.g., radar, propulsion, engine design).

TASK INTERDEPENDENCE AS DETERMINANT FOR TEAM-BASED STRUCTURE

Teams provide optimal structural value if they are strategically positioned where there is substantial nonroutine task interdependence and at critical decision points that have historically slowed cycle time. Identifiable bottlenecks in decision making due to conflicting functional perspectives often signal work domains where team structure is appropriate. The team provides a mechanism to develop common goals and a shared agreement as to the problem or process for resolution.

An analysis of task interdependence should be done to assure that organizations do not over-use teams. A surface examination of the TEAM CAO structural design

offers a possible example. Teams seem to pervade the CAO concept at NAVAIR. This could mean that teams are being used in situations where routine interdependencies, or even low interdependence, would suggest this is an excessively high cost structure. Another possible indicator of the overuse of teams is when personnel report that they are serving on a large number of teams, and spend more time in meetings than they do pursuing their primary task. Declining fiscal resources indicate the need to review team structures and limit their use to tasks and processes having nonroutine interdependencies or historically predictable decision bottlenecks.

Team Composition

Once it has been determined that teams are an appropriate and necessary approach to resolving interdependencies and specific cross-functional decision domains, teams must be constituted. Katzenbach and Smith (1993a, p. 45) define a team as a "small group of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable." Their research findings also argue for keeping team size below 20 members.

Mohrman et al. (1995) also suggest that teams be as self-contained as possible. In other words, team structure should be designed so that there is minimal interdependence between teams, to maximize their ability to operate independent of other teams. The failure to include this design criterion constrains teams in both their speed and flexibility due to the need to communicate, coordinate, and make decisions jointly with other teams. However, this is often very difficult to achieve in knowledge work such as that done by IPTs. The inevitable interdependence among teams requires deliberate mechanisms for integration.

Team Integration

Strategic integration is one important mechanism that aligns teams in a program to a commonly shared definition of mission and goals. While such an integrated strategy is basic to defining the necessary structure to support that strategy, it also has process implications. Shapiro (1992) argues that in developing a "unified holistic strategy" all functional components contribute. Through this participative process, roles and expectations are negotiated and clarified, and resource implications are addressed. Thus, the strategy formulation process itself represents the underlying core values of cross-functional integration.

"Strategic integration is one important mechanism that aligns teams in a program to a commonly shared definition of mission and goals."

An integrative strategy is a mechanism appropriate to any system. However, other mechanisms for integration across teams should be part of the planning of a team-based structure. Appropriate mechanisms might include liaison roles, overlapping team membership, cross-team integration teams, management teams for vertical integration, and process improvement teams (Mohrman et al., 1995). Effective management across team boundaries (i.e., recognizing internal customers) becomes itself a team responsibility. In fact, there is research that shows that the most successful teams are those that effectively manage

interteam relations (Ancona and Caldwell, 1992).

A dominant mode of integration used in DoD acquisition is that of management level teams for vertical integration (see Figure 3). DoD guidance requires that each program have an oversight structure that consists of at least three layers above the program level IPTs (OUSD, A&T, 1996). These include Overarching IPTs (OIPT), Working Level IPTs (WIPT), and Integrating IPTs. Concern regarding the over-reliance on vertical integration is voiced by the CNA study observation that there is a potential risk that the IPT process may become too bureaucratized and top-heavy "with its overarching IPTs, integrating IPTs, and working-level IPTs...actually slowing down and hindering progress rather than facilitating it" (DiTrapani & Geithner, 1996, p. 46). Supporting the CNA study's concern, Galbraith (1995) argues that teams reduce the need for information processing when they are structured and empowered to operate relatively independently. A team-based design that nests teams in a hierarchy of management (or management teams) will significantly diminish the potential beneficial outcomes of expedited decision processes. This is not to suggest that there is no need for hierarchy. But each level of management should have clearly defined product, process, or

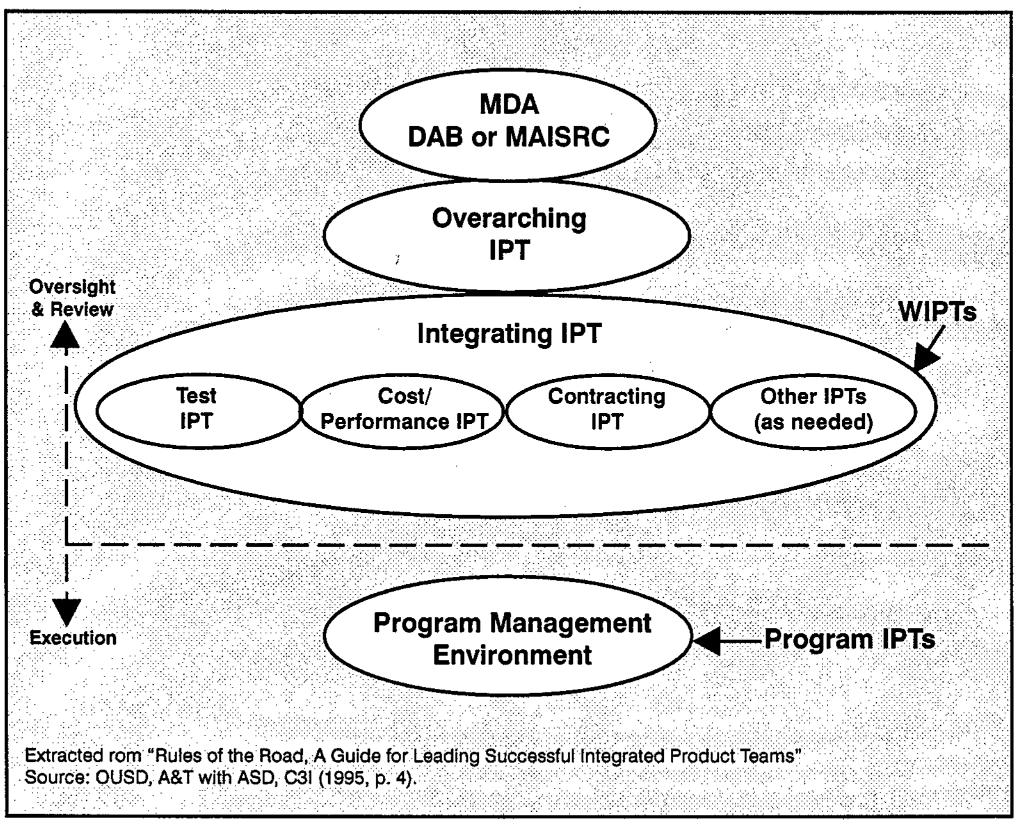

Figure 3. IPT Structure Oversight and Review

service responsibilities with comparable criteria for performance, measures, and rewards as outlined for operational level work teams (i.e., program IPTs).

Process Changes in Team-based Design

Following the open systems model of organizations, structural redesign is only one component that is involved in the large-scale change to a team-based organization. Roles and processes must also be changed to match the requirements of teams rather than individual work. This section discusses the role and task expectations of teams as a whole and team leaders in particular, as well as the changing role of the management hierarchy. In addition, process systems that must be redesigned to support a team-based structure are introduced. The processes referred to here are not the work processes that define the structural determination, but are the support processes that include the information systems, resource allocation systems, performance management systems, decision systems, financial management systems, and training and development systems (Galbraith, 1995).

Control Systems

Shonk (1992) specifies that the responsibility of teams includes measuring, monitoring, and evaluating their own work. To accomplish this, teams must have a clear charter of objectives and expectations, measurement criteria, and information systems to support the gathering and monitoring of team performance. One important measurement criteria is fiscal performance; shifting financial responsibility to programs and teams is an important mechanism for aligning responsibility and authority. In addition, as long as "poor performing teams" are subsidized with either human or fiscal resources, there is a significant disincentive for teams to work hard to reduce costs or personnel requirements. Thus, the reward system, as always, must link rewards with performance. What is different now is the importance of measuring performance at the team as well as the individual level. Both the TEAM CAO (NAVAIR, 1996) and F/A–18 POG (PMA–265, 1996) reference the importance of linking team and individual performance to rewards. Specifically, in commenting on the Ten Guiding Principles of Acquisition Reform, the F/A–18 POG describes the need to delegate authority and reward results as part of "empowering people to lead/manage...not to avoid risk" (PMA-265, 1996, p. 45).

> **"What is different now is the importance of measuring performance at the team as well as the individual level."**

The discussion above illustrates several ways in which organizational control systems must change to be appropriately aligned with a team-based structure. Lawler (1996) states that increasing team-level involvement is an effective source of control that decreases the need for bureaucratic control mechanisms. Control systems that previously supported a functionally defined hierarchy will be inappropriate for measuring and monitoring empowered IPTs comprising members from multiple functions. This has implications for the changing role of the management hierarchy of team-based organizations. The traditional role of

management hierarchy in bureaucratic organizations is to monitor performance and approve (or make) decisions. In a team-based structure that emphasizes the empowerment of teams, higher level managers or management teams now have a new role to establish direction (defining goals and domains of empowerment), develop competence, and provide needed resources (e.g., funding, information, personnel).

PERFORMANCE MANAGEMENT PROCESSES

Another important management role is in the performance management process. With a team-based organization, traditional performance management process responsibilities must be re-evaluated and the appropriate roles of team members, functional manager, and project/program manager must be defined. Because of legal requirements, contracting personnel must have appraisals signed by an appropriately warranted contracting officer. To meet this requirement, IPT members may have two managers (functional and program) giving both informal feedback and formal ratings of performance. This model of dual input for performance feedback recognizes the value of both the expert-functional perspective as well as the program perspective.

"Research on high-performing teams indicates that performance assessments should go beyond the traditional technical contribution and include contribution to team process and team effectiveness."

Finally, the performance management system should consider the potential role team members play in developing capabilities and providing both formal and informal feedback on the performance of their peers. Katzenbach and Smith (1993a) define teams as being collectively responsible for outcomes. As such, there is among effective teams a motivation to cooperate, support, and teach that makes team peers potentially strong resources in the organization's performance management process.

The F/A–18 Team encourages informal team-peer evaluations. The F/A–18 POG offers a sample survey form that can be used by team members to evaluate their peers and the team as a whole. This type of evaluation is designed by the team as a tool for achieving specific team performance objectives. As part of the discussions on team-peer evaluations, the POG states, "These evaluations will be separate from annual personnel appraisals, and can be administered informally every few months. The team can use whatever method best fits its needs, which involves members evaluating the effectiveness of their peers within the team" (PMA-265, 1996, p. 42). A formal team member performance evaluation form is also used as input to the formal appraisal prepared by the functional and program managers.

Naval Air Systems Team (NAVAIR, 1996) recognizes the importance of multiple perspectives on performance in the design of the CAO. IPT members get feedback from multiple stakeholder groups (e.g., related teams, customers, team peers, managers). However, formal performance evaluation remains the responsibility of the program manager with input from the team member's functional manager. A question to be considered is whether this formal appraisal process adequately captures the broader sources of performance

perspective. Research on high-performing teams indicates that performance assessments should go beyond the traditional technical contribution and include contribution to team process and team effectiveness (e.g., Katzenbach and Smith, 1993a; Mohrman et al., 1995). Team members have a unique perspective on this domain of performance.

Establishing a Clear Charter: Team Versus Work Group

The role that IPTs play given the new strategic determination and team-based structure must also be defined. Katzenbach and Smith (1993a, 1993b) make an important distinction between teams and work groups. What distinguishes a "team" from a "group" is the mutual responsibility of members for the total team product. In work groups, members have individual responsibilities that may require shared information and coordination of tasks, but the work products are largely individual. In contrast, teams have both individual and mutual accountability and generate primarily collective work products.

The clear distinction between teams and work groups is that each has unique expectations for individual roles and group processes. Teams require higher levels of coordination among members with a consequent requirement for shared problem solving and decision making. Work groups require fewer meetings, and the focus of meetings is largely information sharing. Because the work of teams is highly interdependent, more consensus building is required and more conflict is to be expected. Similarly, the information required for work groups more heavily emphasizes individual-level tasks and outcomes while teams need both individual- and team-level information for self-monitoring. Finally, each is likely to have different approaches to leadership. In working groups, there is typically a strong, designated leader, while in teams, there are often shared leadership roles among team members.

Team Leadership: Leaders Versus Managers

The shift to teams also requires new definitions of roles. The role of leader/manager changes from supervisor to facilitator and resource provider. This change goes hand in hand with the development of teams' self-management capabilities. Mohrman et al. (1995) also argue for an important distinction between the role of "leader" and the role of "manager." They state that the leadership role may be to act as a liaison (either vertically or horizontally) with other teams; to contribute within the team by coordinating task management or workload issues; or to facilitate group problem solving, conflict resolution, or decision making processes. Katzenbach and Smith (1993a) support this definition. They state that team leadership:

> **"What distinguishes a "team" from a "group" is the mutual responsibility of members for the total team product."**

- keeps the team focus on purpose and goals;
- builds commitment and confidence;
- strengthens the mix and level of team skills;

- creates opportunities for others; and
- does "real work" that contributes to the team product.

These roles can be filled by a single, designated individual, but they can also be deliberately shared as a mechanism for developing self-management skills as part of the strategy of empowerment.

It is important to note that these authors argue it is not necessary for the individuals filling these leadership roles to have hierarchic authority over team members. In contrast, the team "manager" position is hierarchically defined (Mohrman et al., 1995). The responsibilities of the team manager are the major administrative functions including formal reporting authority, performance evaluation, and fiscal authority. A team manager is also responsible for supporting successful team leadership. This includes clarifying the performance criteria for leadership tasks, providing necessary training (in both functional and team leadership competencies), assessing performance, and providing appropriate rewards for team members filling leadership roles.

"The need for a hierarchically defined team manager is defined by both the work requirements of the team and the leadership capabilities of the team members."

The need for a hierarchically defined team manager is defined by both the work requirements of the team and the leadership capabilities of the team members. If the work of a team requires significant liaison work with upper-level integrating teams or negotiating authority for interactions with contractor organizations, a team manager with positional authority may be required. However, the need for a team manager should be re-evaluated as team members develop greater leadership competence in both intrateam processes and interteam communication and negotiation.

Both the F/A–18 POG and the NAVAIR TEAM manuals describe team leader roles and responsibilities. It is important for each organization to prioritize these roles and responsibilities and then use the theoretical framework above as a reference to make distinctions between leader and manager functions. For example, the F/A–18 POG emphasizes the role of team leader by stating, "The word that best captures the attitude and perspective the PMA asks the Level I IPT leads to embrace is 'coach'" (PMA–265, 1996, p. 7). While this term suggests something different from the traditional managerial role, the list of task responsibilities presented in the POG are primarily administrative (e.g., management of cost, schedule and performance; establishment of performance objectives; direction of programmatic tasking). These responsibilities reflect the traditional supervisory role of a manager and, as such, may be in conflict with the role of coach to facilitate and develop team leadership capabilities. The research on effective teams supports the importance of clarifying the expectations for differing roles of leader, coach, and manager.

Cultural Change in a Team-based Design

As noted above, a characteristic of high-performing teams is the development of the self-management capabilities of team

members. Achieving this requires change not only in decision making procedures and information flow, but also a change in the often deeply held values about the traditional role and status of management and labor. Thus, as noted by Secretary of Defense Perry in the opening words of this paper, accomplishing the objectives of IPPD requires cultural as well as structural change.

Empowerment

The empowerment of IPTs is the litmus test of fully achieving the depth of change envisioned for IPPD concept. It is important to state that empowerment does not mean complete autonomy. Decision authority is defined in terms of both the horizontal and vertical interdependence among tasks and teams. Thus, the domain of influence and decision authority must be specifically defined in establishing an IPT's charter, and this will vary with the task requirements of the team.

There is an increasing body of theory and research on empowerment (e.g., Conger and Kanungo, 1988; Thomas and Velthouse, 1990) suggesting factors that can significantly enhance the success of an organization in empowering its workforce. For example, Thomas and Velthouse (1990) propose four dimensions of empowerment, each determined by varying aspects of task and organizational context: impact, competence, meaningfulness, and choice. Each of these dimensions has implications for managerial action and changes in organizational context to support team empowerment. Impact results when individuals or teams see their work making a difference in the accomplishment of team or organizational objectives. When teams make decision recommendations that disappear into a bureaucratic black hole, their sense of impact, and thus empowerment, is diminished. Feedback mechanisms and ongoing measures of performance at the individual, team, and organizational level support the impact component of empowerment. Competence results when team members receive needed coaching, training, or other development in areas of both technical expertise and team skills. Meaningfulness derives from understanding the role of the individual's or team's task to a larger valued purpose. Teams that know how their work relates to the work of others in the larger system and appreciate the importance of their work will have not only an enhanced sense of meaningfulness, but a clearer understanding of process interdependencies. Finally, "choice" is the dimension that is often narrowly taken as the definition of empowerment. Decision autonomy, as noted above, is a necessary component of empowerment, but is dependent on the competence of team members and the interdependencies of team tasks.

> **"A significant indicator of the depth of large-scale change is evident in behavioral norms such as openness of communication, cooperation, trust, delegation, and informal rewards."**

Managerial Values: Modeling New Behavioral Norms

A significant indicator of the depth of large-scale change is evident in behavioral norms such as openness of communication, cooperation, trust, delegation, and informal rewards. Organizational values are deeply embedded, and themselves unobservable, but these

values are demonstrated by the daily behaviors of personnel. Many organizations aspire or pay lip service to empowering the workforce and do not address the multiple organizational factors that must change to support empowerment. A lack of modeling is demonstrated in many organizations when senior managers direct middle managers to "empower" their subordinate teams, but they don't, in turn, empower the middle management teams. Treating empowerment as a superficial change ultimately leads to employee distrust and cynicism with the consequent outcomes in poor performance.

"Treating empowerment as a superficial change ultimately leads to employee distrust and cynicism with the consequent outcomes in poor performance."

A key part of Secretary of Defense Perry's mandate for change through the transformation to the IPPD/IPT concept is the necessity for empowerment. The language of empowerment is prevalent throughout the DoD acquisition documented guidance for IPPD/IPT implementation. But as the research and theory argue, achieving empowered teams requires much more than proclaiming them to be "empowered." Successfully accomplishing empowerment as a deeply rooted change in values and behaviors is determined by:

- the modeling of empowerment by senior managers;
- the formal and informal reward systemæredefined career paths and "what 'pays off' around here"; and
- the adequacy of resource support that can come in the form of training (for both technical and teaming skills), information, and appropriate team decision authority.

Teams that are told they are empowered but not given the necessary training, information, performance feedback, and decision authority will not be successful. Unfortunately, this failure is sometimes attributed to the teams, when in fact the failure is due to limitations of the organization's context or managerial support.

Some Recent Findings on IPPD/IPT Effectiveness

Two recent research reports (Engel, 1997; DiTrapani & Geithner, 1996) present evidence that IPTs are accomplishing some of the desired objectives of reduced decision cycle time, improved quality, and increased satisfaction. Both reports also reinforce many of the theoretically derived propositions outlined in the previous discussion of team-based design as a large-scale change. While several of their findings represent aspects of team implementation that fit more than one category, we use the same categories of structure, process, and culture to present the salient results.

Structural Change

The study of IPTs conducted by the Center for Naval Analysis (CNA) (DiTrapani & Geithner, 1996) included a sample of 11 private contracting organizations, 18 government projects, and more than 80 interviews with program managers. There were several structural design

findings reported. First, the authors state that it is not necessary to convert entire organizations to IPTs. While the authors do not quantify the extent to which an overuse of teams existed in their research sample, the recommendation reinforces the discussion of appropriate analysis of task interdependency and predictability (Mohrman et al., 1995) to structurally determine when teams are appropriate. The CNA study provides further confirmation of the theory in stating that IPTs "are not appropriate for urgent, minor, or routine matters" (DiTrapani & Geithner, 1996, p. 2).

Engel (1997) describes the results of a 1996 study conducted by the Defense Systems Management College (DSMC) that found that 18 of 26 Defense Acquisition Boards (DAB) did not need to convene because there were no unresolved issues; and programs were ready for issuance of the Acquisition Decision Memorandum. In other words, these 18 programs had effectively resolved conflicts that might previously have required upper-level intervention. The elimination of a formal DAB suggests not only that these teams were highly competent, but that they had also been delegated appropriate autonomy to address issues without having to defer to higher levels of authority. The implication is that the Overarching IPT-Working IPT (OIPT-WIPT) structure can allow working-level teams to monitor and evaluate their own work (following Shonk, 1992) and has the flexibility to forego vertical decision approval processes (following Mohrman et al., 1995) when the requirement for integration and coordination at senior levels of the hierarchy is unnecessary.

A problem identified by the DSMC study as reported by Engel relates to team size. One feature of what Katzenbach and Smith (1993a, 1993b) refer to as "high-performing teams" is the appropriate mix of competencies for the task. However, they argue this must be balanced with the need to limit the size of the team for effective decision making. Their recommendation is that teams should be no larger than 20 members. The CNA study findings suggest that team size should be limited to 15 members for effective problem solving and decision making (DiTrapani & Geithner, 1996).

The research cited by Engel (1997) suggests formulating the appropriate team composition often leads to teams that are too large for effective decision processing. Because team composition is defined by the task requirements, an obvious solution to cumbersome team size is to subdivide the task. Inevitably, this creates the need for coordination between two sub-task teams; however, meeting the need for coordination may be more readily addressed than managing effective decision processes with large teams.

"Because team composition is defined by the task requirements, an obvious solution to cumbersome team size is to subdivide the task."

Process Change

Engel (1997) also presents results of the DSMC study that indicate OIPT-WIPT processes that need improvement. In particular, the need is cited for education and training directed toward the processes of IPPD and IPT implementation. This further reinforces that proposition that team-based design requires new processes such

as information exchange, decision making, and career development; successful implementation requires that personnel receive training related to these new processes.

The clarification of role responsibilities and decision processes is supported by the CNA report (DiTrapani & Geithner, 1996) that identifies an ongoing need to assure that team members are empowered to act on behalf of the functional organization they represent. This report recommends that a clear charter be established specifying the authority domain of teams and team members. Such a charter provides clear decision process parameters. Ideally, the chartering process involves team members and managers from both higher level teams and functional competencies in a dialogue to negotiate "boundaries" of empowerment. The dialogue itself represents an important behavioral manifestation of the underlying values change required in the effective implementation of team-based organizations (Larkin & Larkin, 1996).

"Ideally, the chartering process involves team members and managers from both higher level teams and functional competencies in a dialogue to negotiate "boundaries" of empowerment"

Finally, the CNA study reports successful teams have one leader, or at most coleaders. This finding challenges the suggestion of Mohrman et al. (1995) that teams can effectively utilize multiple leaders in complementary roles. It is important to note that the CNA study did not distinguish between leadership and management roles. It is possible that the study finding reflects the administrative and structural necessity for single point of contact within teams that is in line with the recommendation that there should be a single team manager with positional authority and administrative responsibility (Mohrman et al., 1995).

Cultural Change

Another aspect of IPT implementation that DSMC reports as needing improvement is WIPT empowerment (Engel, 1997). Engel's elaboration suggests that functional managers are not delegating adequate decision authority to WIPT members. He describes the necessity for functional managers to adopt a new role that includes defining the limits of empowerment for functional representatives to teams, developing the team members' necessary skills, and allowing delegated decision authority. Engel thus supports Mohrman et al.'s (1995) definition of the changing role of functional manager to one that emphasizes resource provision over direct supervision. Functional managers are responsible for providing program and project managers with fully capable personnel, with capability defined in terms of both functional competence and decision authority.

It is important to note that the DSMC study focused only on OIPTs and WIPTs. The findings suggest that while senior managers espouse empowerment, the next level of managers (serving on OIPTs and WIPTs) don't perceive themselves to be adequately empowered. Research suggests that when mid-level managers perceive they are limited in decision autonomy, they will limit the autonomy they delegate to their subordinates. In other words, constraints on the empowerment

of WIPT members will likely have consequences for the empowerment of program-level IPTs. The DSMC study seems to offer reinforcement of Katzenbach and Smith's (1993b) finding that senior management teams have the most difficulty in meeting the goals of a team-based organization.

CONCLUSION

The Department of Defense has undertaken a large-scale change effort with the implementation of IPPD and IPTs. The purpose of this paper was to highlight research and theory related to large-scale change and team-based organization design as a type of "benchmarking." The research findings and theoretical models provide guidance for organizations to monitor the effectiveness of IPPD processes and IPT performance, and diagnose needed modifications for improved outcomes.

Here we identify specific areas that need management attention within the three domains of structure, processes, and culture (See Figure 2). Three recommendations related to structure are, in sum:

- First, to minimize the potential for over-use of teams, a critical analysis of tasks and processes should be done and teams used only in situations of high or nonroutine interdependence.
- Second, team size should be limited for effective decision making and problem solving.
- Finally, research shows that high-performing teams are those that effectively manage interteam relations. Structural mechanisms that encourage lateral (rather than hierarchical) integration will optimize expedient information processing and reduce the unnecessary "oversight" that can occur when coordination between teams depends on going up the chain of command.

Team-based organization design also has specific process management requirements. The use of measurement to monitor and improve performance can be argued for all organizations. But in team-based organizations, performance must be measured at both the team and individual levels. Rewards must also be linked to quality performance at both the team and organizational level. Performance management processes such as performance appraisals must acknowledge the dual perspective of both the project manager and the functional manager, and they can be further enhanced by team (or peer) and customer input. Finally, the leadership roles and management functions necessary for team effectiveness must be distinctly defined. While management responsibilities may be appropriately assigned to a single individual, it may be appropriate for teams to share leadership responsibilities. Distributed leadership is at the heart of the culture change inherent in effective team-based organizations with empowered teams. But success requires more than adopting the values of participative management. Teams must be given the necessary training, information, performance

"The Department of Defense has undertaken a large-scale change effort with the implementation of IPPD and IPTs."

feedback, and decision authority for self-leadership.

From the perspective of large-scale change, it is important to acknowledge that the changes under way are significant and involve not only structural design but processes, fundamental values, and organizational culture. There is substantial support from research and theory for the potential benefits of the strategic aims of IPPD and IPTs. To achieve those aims, the concepts of large-scale change and team-based design provide the foundation for theory testing that is central to continuous improvement and organizational learning.

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IMPACT OF THE INTERNET ON PROCUREMENT

Judith Gebauer, Carrie Beam, and Arie Segev

We believe that Internet and related technologies will change the role of the purchasing department from a transaction-oriented function to a more managerial function focused on establishing and maintaining relationships with suppliers, third parties, and internal customers, and leveraging corporate buying power. In its new role, procurement will also manage the technological infrastructure necessary to either automate transactions fully or to empower end users to perform many transactions without the direct involvement of the purchasing personnel. These trends have major implications for procurement processes, policies, and technologies, and will change management approaches. We'll survey the state-of-the-art and trends in Internet-based procurement systems, and discuss the results of a recent empirical survey we conducted.

Emerging technologies, such as the newly commercialized Internet and its hypertext-based multimedia-supporting spinoff, the World Wide Web, are raising high hopes of finally changing the picture of costly, time-consuming, and inefficient procurement processes by enabling major improvements in terms of lower administrative overhead, better service quality, timely location and receipt of products, and increased flexibility. With most organizations spending at least one third of their overall budgets to purchase goods and services, procurement holds significant business value (Zenz and Thompson, 1994; Killen and Kamauff, 1995). Growing pressures from increasingly open and competitive markets and increasingly tight budgets in the public sector reinforce the need to reorganize and streamline inefficient procurement procedures.

Although there is some tradition of information technology (IT) in procurement and increasing use of electronic data interchange (EDI) systems by the government and state agencies, especially, most information processing and communication around purchasing are still based on paper and telephone. Available IT systems usually do not cover the full process or are very expensive to set up. Internet and World Wide Web-based applications promise alternatives that are cheaper and easier to set up. In fact, they have the

potential to trigger even more radical changes. Consequently, even traditional users of EDI for procurement are facing significant reengineering and change management challenges.

This article addresses how Internet- and Web-based technology will affect the procurement function. The evolving nature of the field still leaves many questions open and procurement managers frequently wonder whether or not to jump, and onto which bandwagon. After providing an overview of procurement processes and some of the activities that organizations had undertaken to improve performance prior to the advent of the Internet, we take a look at currently available Internet- and Web-based technologies, and the opportunities they open. We also present some short scenarios of what the field of procurement may look like in another decade. In the section "Impact of the Internet on Procurement," we consider the user (buyer) side and present the results of a field study of both companies and government institutions that we conducted in 1997.

Procurement in state and federal organizations, a large part of it military, is somewhat distinct from procurement in private enterprises, because public institutions often have different objectives and constraints. Since they are not profit oriented, but, rather entrusted with tasks of public interest, they face far more regulations than private corporations concerning bidding and purchasing procedures, and are usually under closer public scrutiny. However, the government and corporate activities are intertwined in many ways; indeed, the government procures large quantities of items from private enterprises. Corporate America, on the other hand, has learned much from research and advances in public procurement and logistics, especially in the military sector. In the area of nonproduction procurement, such as office supplies, the practices of government entities and private companies are fairly similar, and the results reported in this paper are applicable to both.

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Background

Procurement

Procurement encompasses all activities involved in obtaining material and services and managing their inflow into an organization toward the end user. It includes obtaining manufacturing supplies for an assembly line as well as obtaining paper and pencils for a bank (Hough and Ashley, 1992; Zenz and Thompson, 1994). Positioned between an organization's internal customers in need of material to fulfill their tasks and external suppliers providing goods and services, this function has to bridge multiple gaps in order to simultaneously manage external and internal relationships, and to balance participants' different goals.

Purchasing—that is, the act of buying goods and services—can be divided into three basic steps: information, negotiation, and settlement (Zenz and Thompson, 1994).

- Information. Prospective buyers identify their needs and evaluate potential sources to fulfill them, gathering information about market conditions, products, and sellers.
- Negotiation. Individual business partners start to interact with each other and determine prices and availability of goods and services as well as delivery terms. Successful negotiations are usually finalized with a contract.
- Settlement. The terms of the contracts are carried out and goods and services

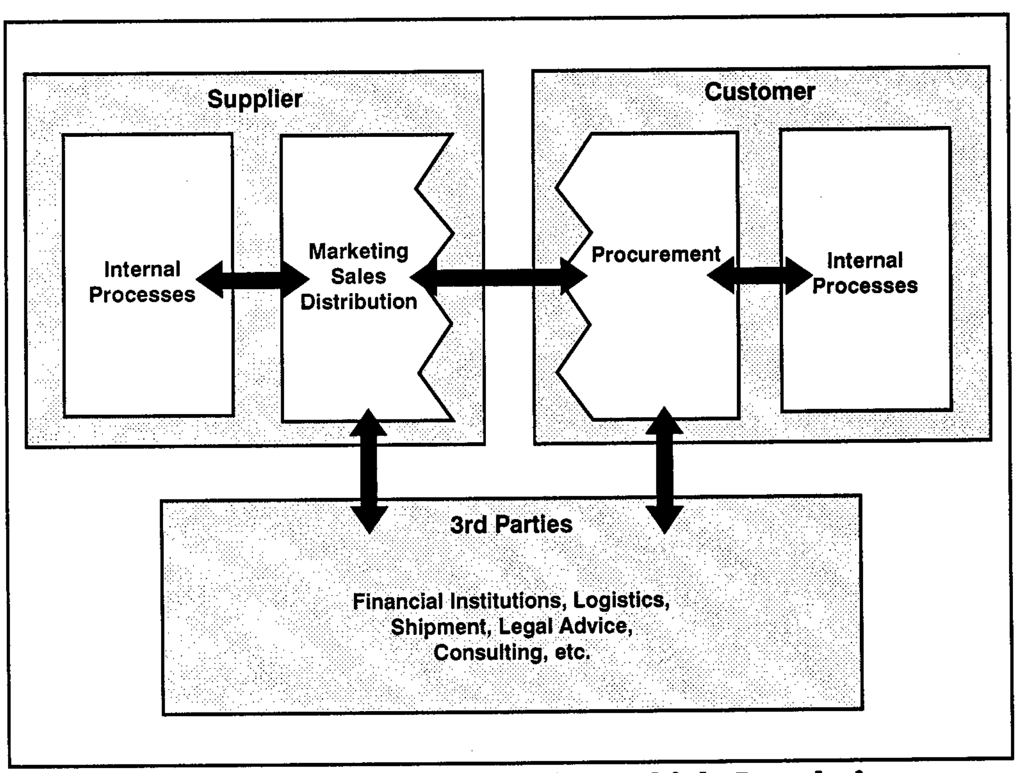

Figure 1. Procurement: Spanning Multiple Boundaries

are transferred in exchange for money or other forms of compensation.

For a richer, more detailed framework see Nissen (1997). The simpler framework is sufficient for discussion purposes and allows us to highlight the electronic commerce developments which are applicable to each of the steps. Procurement processes take on many different forms in reality. Using the types, uses, and the value of the goods purchased, we distinguish between three categories (Hough and Ashley, 1992; Zenz and Thompson, 1994).

- Procurement of raw material and production goods is usually characterized by large quantities, high frequencies, and important and unique specifications; just-in-time (JIT) delivery is often critical.
- Procurement of maintenance, repair, and operating (MRO) supplies is usually characterized by low unit cost and low volume, but relatively high frequency; examples include janitorial and office supplies.
- Procurement of capital goods and maverick procurement means dealing with goods of high value at low frequency (e.g., new factories) or procuring items outside the regular purchasing process, often because of convenience or speed requirements.

While manufacturing organizations emphase procurement of capital goods and raw material, the (growing) service sector, including the government and military, accentuate capital goods and MRO procurement. This paper focuses on MRO procurement, although the IT and changes we address will doubtless touch all three types of procurement. There are several reasons for this. First, we feel that production procurement has already received a large amount of study and attention, and tends to be relatively advanced compared to the other two types. Second, the dollars spent (or saved) in MRO procurement count as direct cost savings, a fact which has been generally under-appreciated. Third, we believe the radical change in IT will give rise to new market-spaces which may, at least in the shorter run, have the largest impact on MRO procurement.

Improving Performance

Most organizations want to manage procurement with the lowest possible levels of risk and investment while still ensuring adequate quality, avoiding duplication and waste, and sustaining the organization's competitive position and outside image (Perlman, 1990; Zenz and Thompson, 1994). While qualitative measures like the level of customer satisfaction or the quality of supplier relationships are emphasized by corporate managers and match strategic requirements, they are relatively hard to gauge. Many purchasing managers prefer more operational transaction-oriented measures like cost, speed of reaction, or delivery time (Fearon and Bales, 1997). Although the biggest payoffs are usually achieved when different methods such as organizational changes and IT are used together to comprehensively reengineer a process, the bottom line results might still be gauged in terms of quantitative measures, such as cost and lead time (Taylor, 1997; Hammer and Champy, 1993).

Purchasing policies and forms are among the most common instruments to standardize and control the purchasing process (Perlman, 1990; Zenz and Thompson, 1994). To cover the wide range of possible situations, however, organizations usually use a large number of rules, and resulting procedures are often complex, slow, and expensive.[1] Another common option to improve procurement performance is the attempt to leverage buying power through central sourcing (Scheuing, 1997), by issuing blanket orders (Zenz and Thompson, 1994), or by establishing close relationships with a selected set of suppliers (MacDuffie and Helper, 1997).

With buying processes typically involving a large amount of information processing and communication, procurement is well suited for IT support and automation throughout all its steps. However, prior to the advent of the Internet, available IT systems often supported only the information phase of production and nonproduction procurement (electronic catalogs) or automated operational activities during the settlement phase, including payment, especially in cases where high volume and frequency justified the high setup cost (EDI) (Sokol, 1995). Systems were often proprietary and not very interactive. Generally, little IT support can be found for the negotiation phase, as well as in capital and maverick buying, where processes are mainly paper-based and done manually (Oliver, 1996; Segev and Beam, 1997).

Now we will address the newest IT—that is, Internet- and World Wide Web-based systems—to explore how it can change procurement, and look at its chances to do so, addressing the question of acceptance among purchasing organizations.

Potential of the Internet to Revolutionize Procurement

Much has been written and said about the potential of the Internet to revolutionize the way business is done. In this section, we will take a closer look at that statement by first outlining the unique characteristics of the Internet, and then providing an overview on the state of the art of Internet-based procurement systems. We will also provide a tentative, futuristic look at the way procurement might be conducted a decade hence, using the characteristics of Internet-based technologies as the guide.

"The Internet, this network of information networks with tens of millions of users worldwide, has some characteristics that make it a very powerful influence on the business world as well as the private sector."

Characteristics

The Internet, this network of information networks with tens of millions of users worldwide, has some characteristics that make it a very powerful influence on the business world as well as the private sector (Ware, Gebauer, Hartman, and Roldan, 1998):

- *Ubiquity and connectivity.* The number of Internet and World Wide Web users is growing steadily, as is the intensity with which emerging technologies are used. As a result, the Internet

is becoming a very flexible and powerful method for organizations to connect with business partners and to access information electronically.

- *Immediacy and interactivity.* Internet- and Web-enabled technologies not only make information available to others instantly, they also facilitate instant interactivity, especially when compared with traditional communication media, such as paper documents, fax, and electronic systems like EDI.

- *Multimedia.* The World Wide Web supports the exchange of information in a broad variety of formats, ranging from text and graphics to sound and video clips, and thus enables the transmission of very complex information.

- *Universal interface and ease of use.* The Internet's open standards architecture manifested in platform independent browser technology helps to overcome the limits of proprietary and closed systems by facilitating data processing and exchange across different technology platforms and different performance capabilities. Additionally, Web browser-based point-and-click interfaces are end user-friendly.

Internet-based Procurement Systems

The features just described give Internet and Web-based systems the potential to support all aspects of procurement:

- Internet search engines help users find items by using keywords supporting the information phase, in particular to find new sources or to fulfill unexpected requirements.

- Internet-based catalogs allow buying organizations to browse, search, and place orders on-line. They combine and extend many features of existing channels, such as the rich content of printed catalogs, the convenience and intimacy of on-line shopping, and the sophisticated searching capability of CD-ROM catalogs. They also let suppliers provide different "faces" to different buyers, and allow all parties to immediately track orders electronically (MacDuffie and Helper, 1997; Perlman, 1990).

- Internet-based EDI links can be less costly than the traditional leased lines and value added services regarding network access and data transmission. As a result, the break-even point in terms of transaction volume becomes lower, especially favoring smaller organizations (Gebauer, 1996). The special features of the Internet and the Web allow the development of interactive applications, enhanced by a graphical user interface with full multimedia support, and thus enable the communication of complex information.

- A growing number of Internet-based on-line auctions and bidding systems supports the negotiation phase by providing a simple negotiation mechanism confined to price alone (Gebauer and Hartman, 1997; Wilder, 1997). Their success is a testimony to the ease with which the Internet connects a large number of dispersed users.

- The most vivid developments in Internet-based procurement systems are probably happening in the area of

MRO procurement, where numerous organizations and initiatives are trying to be the first to present viable business models and software.[2] They are developing systems that let buyers combine catalogs from several suppliers, check the availability of items, place and track orders, and initiate payment over the Internet. Vendors realize the need to streamline procurement processes and to push systems beyond pure transaction processing by adding workflow elements. By integrating individual organizations' purchasing and approval rules, it becomes possible for procurement to let end users do individual purchases, while maintaining control over the process.

New technologies clearly show the potential to trigger significant changes in procurement. The majority of currently available off-the-shelf systems, however, is in a very early stage. Most search engines are not yet sophisticated enough to help locate information in an efficient way. A lack of common standards prevents the easy integration of electronic catalogs from different suppliers and the development of highly valuable "meta-catalogs" (Bichler and Hansen, 1997; Catalogs, 1997). Flaws regarding security and reliability as well as a lack of adequate systems (e.g., to support payment in a flexible way) hinder the widespread use of Internet-based EDI systems. "New generation" MRO procurement systems have yet to prove their viability beyond the pilot stage.

Several organizations have coped with lack of readily available systems by developing high-performance applications in-house. In this context, government organizations play a leading role.

The Defense Logistics Agency (DLA) and the U.S. General Services Administration (GSA) both have developed Web-based systems for the procurement of commodities, MRO supplies, and services. Users in military and federal agencies can now browse electronic catalogs from a multitude of suppliers, review delivery options, place orders on-line, and pay via corporate credit card. Both projects are remarkable alone because of their size: DLA's system holds nearly 4 million items and GSA estimates the current transaction volume handled by the system will double to $55 to $60 million annually by September 1998. Besides, the sophisticated built-in security and payment mechanisms may well serve as models for private corporations and other government agencies. In both cases, the IT systems enabled major changes in the way procurement is done. The central procurement agencies established a general infrastructure in terms of procurement procedures, overarching contracts with suppliers, and the Web-based system that empowers end users to handle purchasing operations by themselves. As a result, purchasing lead times and the related administrative overhead have dropped dramatically.

"New technologies clearly show the potential to trigger significant changes in procurement."

Lawrence Livermore National Laboratories (LLNL) developed a Web-based system for the procurement of prototype parts (Jordan et al., 1997). The approach is remarkable because it is in an area that is usually not well supported by IT but where the overhead costs often surpass the value of the items purchased. Although the

process lead times were frequently unacceptable, EDI was not an option due to infrequent demand patterns and the complexity of the items. The new system supports the entire workflow, from the end user requesting an item through all the steps of setting up and handling a request for quote (RFQ) to the final payment. While the technical specifications for the parts are stored on LLNL's Web server, individual actions are triggered via e-mails internally (e.g., for approval) as well as between LLNL and its suppliers. Setting up secure areas and individualized access rights turned out to be an essential part of the system. With its built-in approval processes and other features ensuring compliance with LLNL's procurement policies, the system, like the systems of DLA and GSA, allows end users to circumvent the procurement department for routine operations. Direct IT-based communication between the "technical experts" (i.e., the end user and the parts supplier) greatly improves the purchasing processes in terms of cost, speed, and errors.

"Automated negotiations and electronic auctions are other areas where big gains have yet to be reaped."

These examples can be considered as first steps on the way to more substantial changes. The next section outlines some scenarios that could be enabled by emerging technologies. Their actual implementation and broad acceptance, however, will not only depend on the availability of the technical solutions, but also on the bottom-line value that they will eventually provide to all prospective user organizations.

A Peak Into the Future

Learning from the impact that the deployment of innovative systems and applications already have had on some organizations, we envision even more radical changes to business practices and organizational structures over the next years as electronic commerce solutions become more mature and more widespread. As a general development we see the role changing between end users and the procurement function consolidate, i.e., new procurement systems will continue to either automate purchasing operations or help push them down to the end user, allowing the purchasing department to concentrate more on strategic and managerial tasks. Automated negotiations and electronic auctions are other areas where big gains have yet to be reaped.

- Starting out with standardized goods, especially MRO supplies, electronic auctions might start to play an important role in many more different market-spaces than today. Involving suppliers and bidders worldwide, they would repeat in real-time, so a prospective purchaser could dial in and see the spot price of paper, chairs, or janitorial supplies and determine whether to purchase now or to wait a while for the price to possibly become more favorable. As more sophisticated description methods evolve, next-generation auctions will also feature more complex items and allow matching of supply and demand not only with respect to price, but also for features such as service quality or speed of delivery.

- Writing up an electronic RFQ and submitting it to the electronic market-

space in general will become easy for buying organizations. Suppliers would be able to electronically contact each other, negotiate a team-based approach, and automatically respond to the RFQ.

- An organization with several decentralized small buyers of the same goods would be able to combine the orders and to leverage its purchasing power to negotiate for the best price, using for example intranet-based internal Web forms for consolidation. The same concept can also be applied in inter-organizational settings where a third party or buying association would act as an intermediary leveraging buying power for smaller and medium-sized organizations using the Internet and Web for communication and as a tool for sourcing.

Ideally, IT will support or even automate all different kinds of procurement procedures across entire organizations by routing technical specifications, approval forms, and payment instructions according to internal policy constraints, external requirements, and market opportunities. As a result, purchasing departments will eventually become composed of mostly managers and systems integrators, and less of clerks, secretarial staff, and administrative support. Additionally, the determining factor of geography will diminish, freeing organizations to obtain the best deal and the most appropriate products from anywhere on the globe.

Although our peek into the future is based on some developments that are already visible, their newness and the immaturity of available technology and standards make it very difficult to forecast future developments. It is not clear what future Internet-based procurement systems will look like and how well they will be accepted by buying and selling organizations, whether common standards will evolve and what they will look like, and what the resulting changes in procurement processes will eventually be. To offer a starting point and to help overcome the current lack of empirical data necessary to answer these questions, we conducted a field study among buying organizations. The next section outlines the design of the study and discusses its results.

"It is not clear what future Internet-based procurement systems will look like and how well they will be accepted by buying and selling organizations...."

Impact of the Internet on Procurement

Research Questions and Field Study Design

In early 1997, the Fisher Center for Management and Information Technology at the University of California, Berkeley, started an extended field study, partly in cooperation with CommerceNet and the *Journal of Internet Purchasing* (Segev, Beam, and Gebauer, 1997). Among others, the study attempts to answer the following research questions:

- What is the current state of the practice in purchasing concerning the use of IT in general and the Internet in particular?

- What are the requirements of the procurement function and what is the perception of the Internet's potential to help improve procurement?

- What types of relationships do organizations currently have with their suppliers and how might the Internet change this picture?

- Can we isolate organizations that are "leaders of the pack" in terms of IT use in their procurement function? Which factors differentiate them from the rest of the sample?

- What are the obstacles to purchasing on the Internet?

As a first step, we conducted an empirical survey among buying organizations using a Web-based questionnaire and gathered additional knowledge from telephone conversations with purchasing managers, case studies, and literature research. The results reported here are based on 60 responses, which we collected primarily between April and July 1997. The small sample limits the depth of possible interpretation of the results, as does the fact that it is somewhat skewed toward organizations that can be considered rather open towards the use of emerging technologies. This is due to many factors, including the fact that only Web-capable organizations could fill out our on-line survey form,[3] and organizations that took the time to respond to the survey were likely to have made IT use in procurement a priority.

The participating organizations cover a broad range of business types, with computer software (15 percent), manufacturing (13 percent), and government (12 percent) accounting for the biggest chunks. More than two-thirds (35 percent) of the participants identify themselves as primarily manufacturing organizations, while 65 percent are primarily service businesses. Based on a compilation of annual sales, number of employees, and annual purchasing volume (Table 1), 28 percent are small organizations; 24 percent are medium, and 40 percent are large organizations.

Table 1. Size Categories[a]

Size	Annual Sales Volume	Number of Employees	Annual Purchasing Volume
Small	$10 M or less	500 or less	$1 M or less
Medium	$10 M to $1 B	500 – 10,000	$1 M to $50 M
Large	$1 B or more	10,000 or more	$50 M or more

[a] Organizations were ranked according to the majority of the categories into which their annual sales volume, number of employees, and annual purchasing volume fell. In cases of doubt, we prioritized the annual purchasing volume.

Results and Discussion

Current Purchasing Practices as They Regard IT Use. The responses to our survey show that procurement is still far from being revolutionized by the Internet. While "conventional" IT such as electronic catalogs as well as EDI systems are in use at half of the participating organizations, there is no broad adoption of Internet and Web-based technologies. To date, most of the communication between buying organizations and their suppliers is not even IT supported, the phone and fax machine being the most important means of communication. Even relatively inexpensive electronic systems such as e-mail were quite frequently rated as not very important. In some cases, participants reported that they were unable to fill in the survey on-line because the procurement function only had access to very few Web stations, which were not available for such tasks.

Although business-to-business (B2B) applications are not yet in widespread use (Figure 2), 31 percent of the responding organizations plan to increase the number of electronic links over the next 12 months by at least 20 percent. This indicates not only a potential increase for the use of Internet technologies, but also a starting point for raising awareness among organizations about possible applications.

Analyzing the functionality of B2B applications in more detail reveals that larger organizations are more likely to have systems in place that allow the electronic transfer of data, JIT replenishment, and suppliers' access to internal data and that integrate B2B applications with internal systems. Manufacturing organizations report more often that they allow

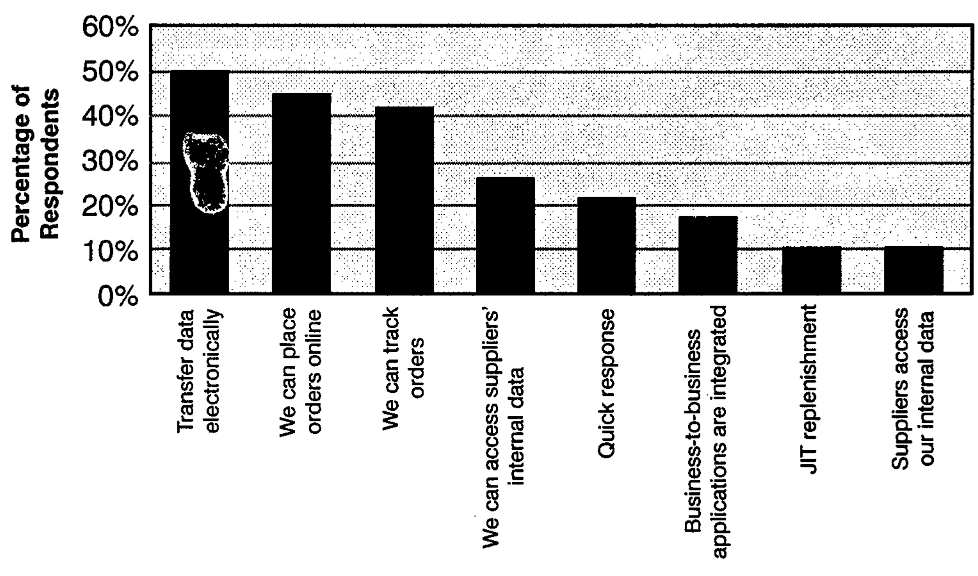

Figure 2. Functionality of Business-to-Business Applications

suppliers to access their internal data, while service organizations are more often the ones that have access to suppliers' data and report that they can place and track orders on-line.

Requirements of the Purchasing Function and the Role of the Internet. To learn more about the requirements of the purchasing function, we asked respondents to list the three most important measures of success of the purchasing department and to rate the department's success with respect to that measure. We summarized the answers in categories (Table 2). The results clearly show the importance of issues such as cost, time, (internal) customer satisfaction and quality, and also the difficulty of managing cost control and time issues.

Although the current use of the Internet is weak, the general attitude of our participants toward its use is positive and indicates confidence that it will help to improve procurement. The majority believes that the Internet will increase the efficiency of the supply chain by facilitating inter-organizational information sharing (66 percent), that it will reduce the length of the supply chain by making it easier to locate suppliers (60 percent), and that it will help handle situations of exceptional demand better (57 percent).

Impact of the Internet on buyer-supplier relationships. Almost half of the participants (47 percent) indicate that most or all of the relationships with their suppliers are moderately distant, so neither very close nor very distant relationships prevail. Larger organizations generally have closer relationships than smaller ones. High setup costs for electronic links, as they are typical for EDI and JIT

Table 2. Purchasing Success Categories

Rank	Measurement	Interpretation	Importance[a]	Success[b]
1	Cost	Cost of items purchased as well as total cost of ownership	91	3.14
2	Time	Timely delivery, fast order processing	66	2.97
3	Satisfaction	Internal customers (can be broken into price, quality, and order fulfillment, i.e., accuracy and time to fulfill), selection, and characteristics of the internal process itself (friendliness of the people, etc.)	57	3.52
4	Quality	Ability to provide high-quality goods	43	3.11
5	Stock	Inventory management and ability to keep high (sufficient) stocking	26	3.25
6	Value	Value delivered to the organization	24	3.00

[a] We weighted the answers according to the following ranking system: A first-place performance measure was given 3 points; a second-place was 2 points, and a third-place measure was given 1 point.

[b] Success is rated on a scale of 1 (unsuccessful) to 5 (extremely successful).

systems, can be better justified in the case of close links with a business partner, since they foster trust in an ongoing relationship. Consistently, these systems are more frequently in place at larger organizations than at smaller ones. For smaller organizations, the Internet promises to link them more closely with their suppliers. They hope it will help them achieve the close and interwoven relationships that larger organizations have in place already, at lower setup costs and less organization-specificity than is required by other technologies (such as EDI) over private leased lines.

We asked the participants about their perception of how the Internet will affect the relationships with their suppliers and generally affect procurement. The answers were not at all uniform, which might be due to the newness of the medium. Thirty-three percent believe that regardless of past events, the Internet will decrease the number of suppliers over the next 5 years. Thirty-seven percent believe the number of suppliers will actually increase, while 27 percent believe there will be no impact. While small organizations think the Internet will rather increase the number of their suppliers, medium sized and large organizations tend to expect a decrease or no impact.

IT leaders: Are they different? Oftentimes, valuable lessons can be learned from the actions of early adopters of new technology. We divided the responding organizations into four major groups (leader, moderate, little, and very little), using the degree of sophistication and integration of their IT systems as the criteria.[4]

The leaders are about evenly spread between organizations of all sizes. They seem to be slightly more prevalent in service, rather than in manufacturing industries, where half of the sample was in the "very little" category. The leaders and moderate users of IT also appeared to operate in less stable environments than did the organizations which used little or very little IT in purchasing. We need more research to answer the question of whether unstable environments require more use of IT to adapt, or if the unstable environment and increased use of IT in the purchasing function are both effects of some other root cause.

Another interesting suggestion here is that the leaders more often have written and detailed purchasing procedures in place, which they follow more closely than the other groups. This could reflect necessary planning before an information system can be implemented, or perhaps an overall management commitment to purchasing. Either way, the leaders in IT usage appeared to be also leaders in procurement policy planning and execution.

> **"Oftentimes, valuable lessons can be learned from the actions of early adopters of new technology."**

There also appeared to be a small difference between the groups with respect to purchasing priorities. For the leaders, quality was the most important measure, while for the other organizations, cost was the most important measure. It is also interesting to note that the leaders did not rank customer satisfaction among their top three, whereas the other three groups did. Perhaps this indicates the leaders are trying to satisfy other criteria; it could also mean that "quality" encompasses customer satisfaction.

Obstacles to purchasing on the Internet. What stands in the way of increasing the use of the Internet and other emerging technologies, and eventually helping to move the procurement function from a transaction-based orientation to a more strategic viewpoint? The comments of our participants and the survey data showed that the immaturity of technology is a largely inhibiting factor, but not the only one. The most commonly named obstacles are:

- security concerns;
- inefficiencies in locating information; and
- lack of adequate tools and systems.

Organizations also find it is difficult to change current organizational systems that rely extensively on interpersonal communication (telephone, face-to-face, fax, etc.). Many organizations have widely differing systems in place for different suppliers. This lack of interoperability and the lack of standards make it difficult to pull all buyers and suppliers together into a single protocol or a few market-spaces for buying and selling. Despite steady growth, the current use of Internet-based technologies has not yet reached critical mass. Organizations willing to communicate via e-mail often find their business partners not yet capable of receiving messages.

"Although Internet-based procurement systems have not yet been adopted on a broad scale, the general attitude of buying organizations is positive and inquisitive."

Additionally, there may be a lack of top management support and vision. This is understandable, because not even researchers and market analysts are yet sure of the exact direction electronic purchasing will move. All these obstacles are both technical and managerial, and cannot be simply solved by a fast Internet connection or yet another departmental reorganization.

Conclusions and Areas of Further Research

Although Internet-based procurement systems have not yet been adopted on a broad scale, the general attitude of buying organizations is positive and inquisitive. They are beginning to realize the potential of emerging technologies to change corporate procurement; smaller organizations, especially, now see the chance to establish electronic links with their suppliers in ways that were once reserved for large players. Especially "new generation" MRO procurement systems promise to bring organizations one step closer to a scenario of integrated, yet modularized systems, which are flexible enough to handle all the different kinds of purchasing routines an organization usually has in place. Built upon open standards, emerging technologies also promise flexibility when it comes to adding or changing new functions and partners in order to keep up with changing business requirements.

In line with "historic" business process reengineering projects, benefits can be reaped not only by automating operations, but maybe even more from developing an infrastructure of empowerment for end

users. Letting them "shop on their own" will leave the procurement department with more resources to focus on strategic tasks (e.g., establishing and maintaining close relationships with suppliers and business partners), eventually leading to streamlined processes and leveraged buying power. In order to overcome the limits to empowerment, since end users are not always keen on "having to do the work," ideal new systems might give them a choice.

Since currently available systems are far from mature and not even all aspects of procurement are covered yet, the advent of the "brave new world" depends heavily on issues like the availability of manageable technology and whether organizations actually realize the benefits of deploying it. Academic research will continue to play an important role in raising awareness and spreading news of innovative applications, as will the trade press and industry associations. Given that technology changes at a very fast pace and systems that create sustainable competitive advantage will always require some customization in order to provide unique value, organizations need to consider their Internet plans as part of a larger strategy. Developing applications using new technology for the sake of it will surely initiate the legacy systems of tomorrow—that is, fancy "islands of Webification."

More research is needed to fully answer our research questions. Close interaction among all market participants (suppliers, buyers, and technology vendors) is necessary to continuously identify technology requirements and, subsequently, to develop systems that provide bottom-line value and thus incentives for adoption by all parties. We will intensify our current field studies by collecting more data points and performing deeper data analysis, as well as compiling additional case studies. We will also extend it by including the suppliers' side of the picture and learning about their requirements and intentions to participate in the adoption of current systems.

ENDNOTES

1. At the University of California, for example, processing a purchase order runs over $200 on average.

2. For example, Actra Business Systems, Elekom, Ariba, and CommerceOne.

3. We did offer paper-based and e-mail versions of the questionnaire.

4. Evaluation criteria were the use of e-mail, file transfer, EDI, electronic funds transfer, and electronic catalogs, the percentage of transactions done with business to business applications, and the sophistication of electronic networks an organization participates in.

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VIRTUAL SYSTEM ACQUISITION: *APPROACH AND TRANSITIONS*

Walt Scacchi and Barry Boehm

There is a pressing need to make software system acquisition more agile and adaptive, through evolutionary modeling, simulation, and development of the system being acquired. Here we'll describe a new vision for the re-tooling and reengineering software system acquisition into a form we call VISTA, denoting an approach to the virtual acquisition of these systems. We will describe this new approach, and then discuss the technical and organizational transitions that must be investigated and managed to ensure the eventual success of such a radical change to software system acquisition.

The acquisition of major software-intensive systems is often problematic. Recent reports from the U.S. General Accounting Office (GAO, 1995; GAO, 1997) describe a number of problems with the way complex systems are acquired. The current acquisition problems include:

- difficulty in establishing viable and cost-effective system requirements;
- overly optimistic cost, schedule, and performance estimates;
- concurrent development and production of systems; and
- commitment to system production before adequate demonstration or testing that determines system viability is completed.

To no one's surprise, modern and future weapon systems increasingly represent software-intensive systems. In addition, the Department of Defense (DoD) and other government agencies rely on the acquisition and use of computer-based information systems to manage their recurring organizational and operational activities. Many of these management information systems are often running on outdated computing platforms that must be replaced or modernized.

The DoD has established acquisition strategies that move it toward commercial acquisition practices. One strategy embodies the idea that the feasibility and ability to produce advanced technologies can often be demonstrated before they are incorporated into acquisition programs. For example, the use of advanced concept

technology demonstrations can more directly involve war fighters and users in demonstrating the operational feasibility of new technologies and concepts before commitments are made to full-scale acquisition. Another strategy rooted in the Defense Acquisition Workforce Improvement Act (DAWIA) establishes benchmarks for a more professional acquisition workforce with defined training and education requirements, and acquisition career paths. The goal of this act is to provide an acquisition workforce that is more responsible for improving program costs and schedule estimates. Finally, in 1994 the Office of the Secretary of Defense began pursuing a strategy to reengineer the systems acquisition review process. This includes an effort to reduce acquisition costs (including overhead costs) through the adoption of business processes characteristic of world-class commercial buyers and suppliers.

The overall way in which the federal government conducts its acquisition practices has been reviewed and redesigned in response to the Federal Acquisition Streamlining Act (FASA) of 1994. Among other things, the FASA requires incentives and a performance-based approach to managing acquisition programs. This emphasizes streamlining the acquisition process and proposes greater reliance on commercial products and processes. Also, concepts for applying commercial practices to DoD software system acquisition have been addressed in Defense Science Board reports.

Thus, we are at a time when there is substantial opportunity to rethink how the acquisition of software-intensive systems should occur to address the recurring problems. At the same time, we should pursue new opportunities to reengineer the systems acquisition process that can realize savings, efficiencies, increased satisfaction, and continuous improvement. Similarly, we should provide a strategy for managing the transition to these reengineered system acquisition processes, as they can represent a radical departure from current practices. Subsequently, we seek to explore how these opportunities can be pursued through use of advanced information processing tools, techniques, and concepts. Our objective is to make the acquisition of software-intensive systems more agile and adaptive. Relevant information technologies include those for:

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- re-tooling system acquisition processes to better assess the feasibility of system acquisitions;
- digital libraries for organizing and sharing information gathered during system acquisitions and program management; and
- Internet-based electronic commerce services and capabilities for streamlining procurement actions, lead times, and supply chain logistics (Nissen, 1997; Scacchi and Noll, 1997, Scacchi, et al., 1997).

However, in this paper and in related materials (Boehm and Scacchi, 1996), we focus our discussion on the first of these areas.

Steps Toward More Agile Acquisition of Future Systems

In general terms, our overall goal is to address the recurring problems that plague system acquisition efforts. Our approach suggests ways in which new modeling and simulation techniques can help in reengineer software-intensive systems acquisition by the DoD and other government agencies. This means that we seek to identify new concepts, tools, and techniques for acquiring software-intensive systems that fulfill four goals: First, to establish viable and cost-effective system requirements. Second, to establish realistic cost, schedule, and performance estimates. Third, to mitigate against concurrent development and production of systems. Fourth, to enable adequate demonstration and testing of system viability before a commitment to system production must be made. Based on the results from a series of workshops and Blue Ribbon Panels of leading military, industry, and academic experts that addressed the problems of large-scale software system acquisition (Boehm and Scacchi, 1996), we can identify five issues involved in achieving the overall goal.

First, we need to baseline our current understanding of strengths and weaknesses of current "as-is" process capabilities for acquiring software-intensive systems. Guidelines, best practices, and lessons learned are being collected and disseminated. The Software Technology Support Center (STSC, 1995) and the Software Program Managers Network (SPMN, 1997) have assembled recent collections. Nonetheless, we also need to understand how they are employed, and to identify the operational problems that may inhibit their application and success.

> **"First, we need to baseline our current understanding of strengths and weaknesses of current "as-is" process capabilities for acquiring software-intensive systems."**

Next, we need to develop scenarios for new "to-be" acquisition process capabilities that exploit an evolutionary "virtual" approach to the acquisition of software-intensive systems. Such an approach emphasizes the incremental acquisition of virtual prototypes for a new software-intensive system. These prototypes start as models of the intended system. These system models can be analyzed and simulated to determine which system requirements and risks have been addressed. As familiarity and confidence with the prototypes'

increases, their realism and functionality increases with the incremental integration of system components. In this way, virtual prototypes of systems can be incrementally modeled and iteratively reconfigured with simulated or actual subsystem components. The development and production of a growing number of complex electro-mechanical assemblies are now designed, tested, and refined through the use of computational models and simulations as virtual prototypes (Garcia, Gocke, and Johnson, 1994).

"The goal is to minimize cost, maximize customer satisfaction (via system performance and quality attributes) and minimize acquisition and development cycle time."

Similarly, the availability of Battle Labs suggests the use of virtual battlefields and command centers for trying out or exercising complex defense systems in alternative scenarios, through computer-based modeling and simulation test-beds operating within networked laboratories (Cothran, 1996; Wilson 1996). Accordingly, approaches such as these may also prove to be effective in supporting the acquisition of software systems. In this way, viability and cost-effectiveness of system requirements can be demonstrated, validated, and refined in an incremental manner. Similarly, estimates for the cost, schedule, and performance of an ever-more-complete actual system can also be developed and refined incrementally. Subsequently, we should also consider developing methods and scenarios for how to shift from the "as-is" to the "to-be" acquisition process we envision.

Third, we need to articulate the design and operational concept for a wide-area modeling and simulation infrastructure that's primary purpose is to serve as a test-bed and delivery platform for agile acquisition of software-intensive systems. Such an infrastructure may need to support collaboration and resource sharing between software system researchers and developers at geographically distributed sites. It may operate as a modeling and simulation collaboratory (Kouzes, Meyers, and Wulf, 1996) for software system acquisition. Similarly, such an infrastructure may need to support a hypermedia repository or digital library of technical data and information that can be accessed and shared over the Internet or World Wide Web (WWW). Such a digital library should store and organize access to software acquisitions assets. These may include publications, model and simulation libraries, reusable software subsystem components, system demonstration scenarios, multimedia presentations and annotations. In addition, the digital library may provide paths to super computing environments that support massively parallel simulations, etc.

We also want to understand how future acquisition processes or capabilities might exploit the full range of technology strategies and options at hand. The goal is to minimize cost, maximize customer satisfaction (via system performance and quality attributes) and minimize acquisition and development cycle time. Relevant technologies that can support this goal include the use of knowledge-based systems, multimedia, the Internet, electronic commerce for selling and buying software components, architecture-based software system development, high-performance

computing and communications, etc. Will new modes of academic research or industrial activity be required to most effectively support agile acquisition? If so, what are they? Similarly, what institutional or marketplace incentives are needed to help make them happen?

Finally, we need to set priorities and estimate the relative costs and benefits of candidate investments in modeling and simulation capabilities that support software system acquisition. We need to identify areas in which needs can be met largely through available technology. And we must identify areas in which acquisition research and the development of automated acquisition support environments promise an attractive return-on-investment.

Background and Foreground

We may now be at the threshold of a new era in the acquisition and development of software-intensive systems. From this point, we can look back to where we have been and what we have experienced. Then we can look forward toward the horizon to see what lies ahead.

Looking Back: Why Use Models and Simulations to Support Program Acquisitions

In looking back, we see that the acquisition and development of software-intensive systems was guided by the classic "waterfall" system life cycle. In such an approach, DoD customers were expected to be able to articulate their needs and requirements for new system capabilities prior to system development. Developers or contractors could then take these requirements as their starting point. Then they would systematically develop, test, and deliver results to the customer according to a sequence of development milestones and documentation standards.

While this approach has much rational appeal, its practice and outcome has often been less than satisfactory. The overall experience was that it was difficult for customers to fully articulate their system requirements prior to the beginning of system development. Furthermore, when system development took years, the customer (and the developer) recognized their requirements were changing, sometimes very rapidly. Consequently, far too many systems developed under contract were delivered that did not meet critical system requirements. In the worst cases, the software systems were effectively nonoperational. Subsequently, more customers and developers began to recognize that perhaps these shortfalls in software acquisition and development were systemic, rather than simply characteristic of particular programs or development organizations.

"...we need to set priorities and estimate the relative costs and benefits of candidate investments in modeling and simulation capabilities that support software system acquisition."

In response to the seemingly inevitable shortfalls with the classic approach, efforts to find an alternative began. This led to an incremental "spiral" development approach. In the classic approach, there is little visibility regarding operational software system capabilities until late in the development cycle. In contrast, the spiral

approach embraces a more evolutionary and iterative development model. Accordingly, operational software capabilities become visible in evolutionary increments, rather than all at once. Subsequent development iterations then add and integrate more increments until the final system is ready. Thus the spiral approach seeks to build and deliver software-intensive systems through evolutionary development. Consequently, guidelines now put forth in military or public standards such as MIL-STD-498, ANSI J-STD-016, and US 12207 encourage use of an incremental spiral approach when acquiring and developing software intensive systems.

"Program managers, contractors, customers, and acquisition directorate staff can use models and simulations coordinated by a negotiation support system."

Why should we use models and simulations to support the incremental acquisition of complex software systems? In simplest terms, we can identify three reasons: First, to facilitate early identification and reduction of risks associated with complex system acquisition programs. Second, to better understand what kinds of system requirements and architectures are feasible and affordable given various programmatic and technological constraints. Third, to gain insight into how to better manage the system engineering effort so as to improve the overall likelihood of a successful acquisition effort.

But the creation, use, and reliance of models and simulations to support incremental acquisition efforts cannot guarantee such outcomes. Clearly, models and simulations of complex systems will never be more than assumption-laden approximations of the systems being acquired. This is the fate of all models and simulations (Smith, 1996). Nonetheless, the process of building, using, and evolving such models and simulations in support of decision-making activities in large system acquisition efforts can be characterized as one of consensus validation (Dutton and Kraemer, 1985). Thus, the value of supporting system acquisition through modeling and simulation will be found in the process of working with them, rather than in the calculations performed along the way. Modeling and simulation can be used to help identify where consensus can be established and validated, as well as to identify where disagreements can be found, so their consequences can be examined.

Program managers, contractors, customers, and acquisition directorate staff can use models and simulations coordinated by a negotiation support system. Such a system can support the elicitation, capture, and validation of points of agreement among system acquisition participants. In addition, such a system can help these people surface assumptions, debate their merits or implications, and negotiate alternative system configurations and functional features (Boehm et al., 1995). In this manner, computer-based models and simulations, together with an information sharing and negotiation support environment, provide a more articulate medium to express opinions and stimulate alternative conceptions of system acquisition problems and challenges. Without such articulate models and simulations, system acquisition participants are left to their private intuitions and

conceptions of system design, program cost drivers, and the like. This in turn can easily obscure problems in system design or performance, increase the likelihood of miscommunication and systemic conflict, and increase the likelihood of problematic system acquisition and costly post-deployment support of the resulting systems. Thus, we believe that models, simulations, and associated environments can play a significant role in supporting the incremental acquisition of complex software systems.

Looking Ahead: An Emerging Case Study

We see many opportunities for improving the effectiveness and responsiveness of the acquisition of software-intensive systems across their life cycle. Many of these opportunities result from the availability of new technologies and development capabilities that make the acquisition of software-intensive system more agile. Agility can lead to more cost-effective, more timely, and higher quality results in software system acquisition. Modeling and simulation technologies that support virtual prototyping (Garcia, Gocke, and Johnson, 1994) and simulation-based design of complex hardware systems are being used to support major program acquisitions, such as that for the SC–21 class of battleships (SC–21, 1997). We believe a similar effort is appropriate for acquisition of the large software systems associated with such hardware systems. Accordingly, by examining the currently proposed software systems intended to support SC–21-class ships, we can better motivate and articulate a vision for how new modeling and simulation technologies can be used to help support the incremental acquisition of complex software systems.

There is no single architecture or final design envisioned for SC–21 ships. Instead, the SC–21 ships could be built following the commercial practice of developing a product line with common subsystems or reusable designs. Figure 1

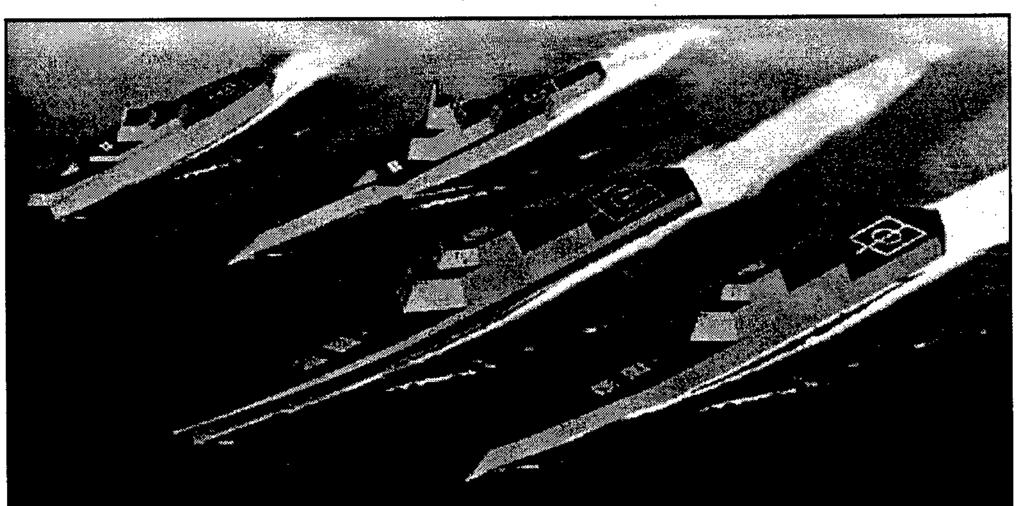


Figure 1. Alternative Overall Architectures for SC–21 Ships (SC–21, 1997)

helps show what this means. Here we see four alternative views of the overall architecture of SC–21 ships. The intent to enable the choice of the final architecture of each ship to be determined by emerging need or threat. Nonetheless, any such SC–21 ship will still have some configuration of common subsystems for weapons, command deck, flight operations, etc. As such, all of the alternative versions of ship architecture displayed in Figure 1 would be members of the SC–21 product line.

Building these ships according to different architectural configurations represents a fundamental change in how such ships will be acquired, developed, and operated. The system life cycle for these ships will be iterative, incremental, and ongoing. Figure 2 conveys a vision for how various computer-based modeling and simulation technologies, such as virtual weapon system modeling and simulation-based design, may be employed to support the acquisition, development, and operation of SC–21 ships.

SC–21 ships will be software-intensive systems. All major subsystems and overall system capabilities supporting each ship's operations depend on software. Figure 3 proposes a suggested allocation of shipboard subsystem capabilities that will be implemented in software systems. Total number of software instructions or source lines of code (SLOC) to realize the proposed capabilities is estimated at

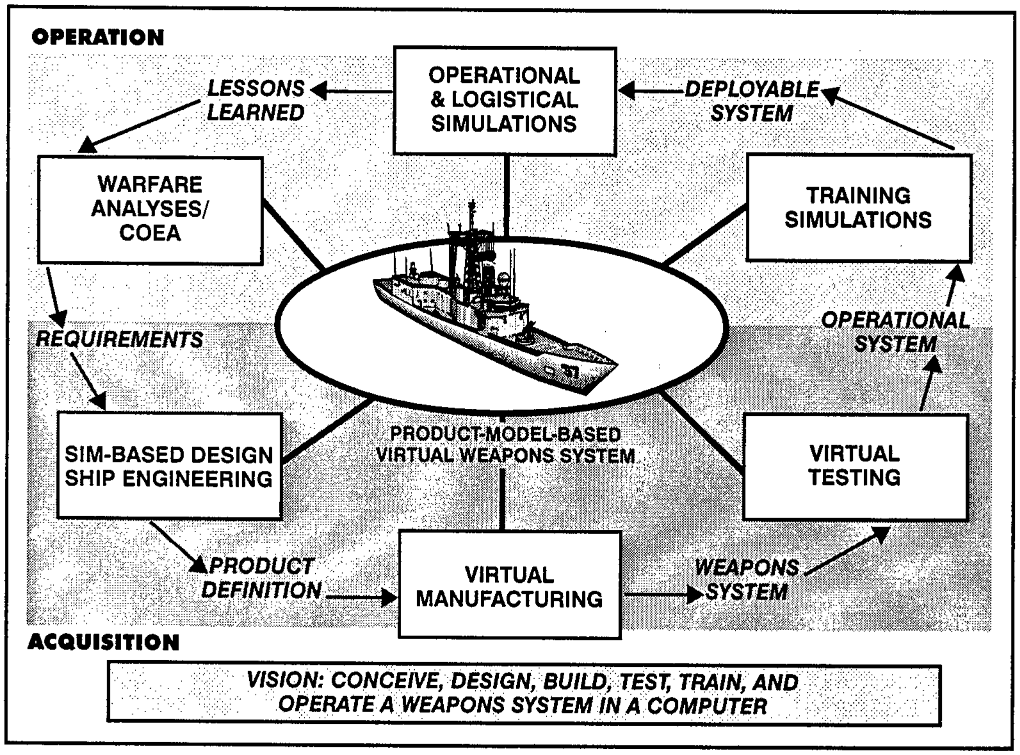


Figure 2. Vision for How Modeling and Simulation Can Support New System Acquisition and Development (SC-21, 1997)

greater than 8.4 million SLOC. Much of this software can potentially be reused across the SC–21 line of ships, however. Nonetheless, development costs for software of this size and complexity is often estimated in the range of $100 million to $1 billion. Thus, what can be done to help understand the feasibility of alternative software subsystem architectures associated with the SC–21 ship family, and manage the progress, costs, and risks associated with the acquisition and development of this software?

At present, there is an emerging consensus for what technological capabilities are needed to support the acquisition and development of software-intensive systems such as the family of SC–21 ships (Boehm and Scacchi, 1996). Much like the SC–21 family of ship hardware and major subsystems employs recent advances in modeling and simulation technologies, similar technologies could be brought together to support the acquisition and development of the software systems for these ships. Accordingly, we can now outline a strategy for how this would work. We then follow with a discussion of the technological and organizational transitions likely to be encountered in the course of adopting this strategy. Along the way, we describe an approach for how to assess the feasibility of complex software systems through its incremental development spiral. In addition, we describe a road map that lays out the research, technol-

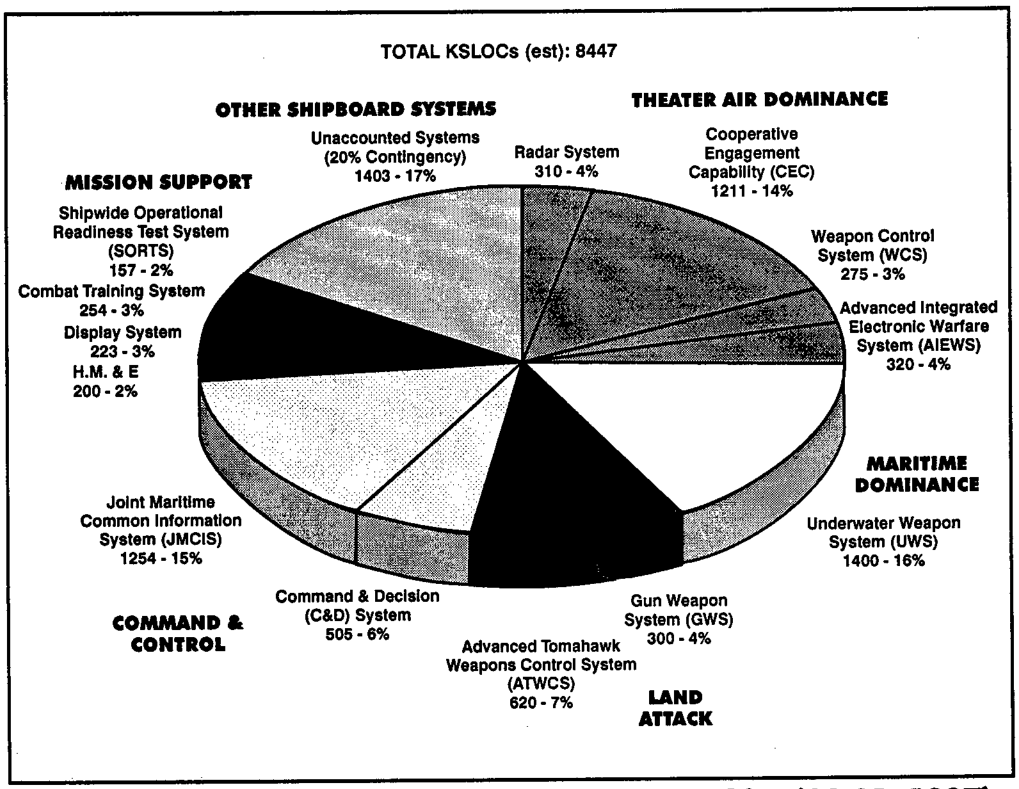


Figure 3. Software Systems Proposed for SC–21 Ships (SC–21, 1997)

ogy, and usage needed to support the acquisition of software systems, such as those for the SC–21 line of ships.

The Virtual System Acquisition Vision

The virtual system acquisition (VISTA) of software systems refers to a strategic process by which an evolving series of ever more complete and operational system versions are acquired through a series of short duration acquisition life cycles. In this way, emphasis is on reframing and reducing acquisition cycle times from years to months (or weeks!) so as to focus attention on the incremental and iterative acquisition of the evolving capability associated with the target software system.

"The virtual system acquisition (VISTA) of software systems refers to a strategic process by which an evolving series of ever more complete and operational system versions are acquired through a series of short duration acquisition life cycles."

Reductions in acquisition cycle time enable an increase in the number of incremental acquisition cycles over time. The VISTA approach seeks to help more rapidly identify, address, and resolve the risks associated with the acquisition and development of complex software-intensive systems (Boehm and Scacchi, 1996; GAO, 1997; Haimes, Schooff, and Chittister, 1997). Thus, we need tools that enable customers and developers to rapidly model, incrementally evolve, and satisfy (sub) sets of system capability requirements in each iterative system version. Early acquisition cycles need only to focus on acquiring systems that represent computational models and simulations of the operational capability of the target software system. Later acquisition cycles then focus on incrementally evolving or replacing the models and simulations with fully operational system modules. In this manner, there will always be an operational version of the system to evaluate and demonstrate throughout the system's acquisition and development cycle.

Models and simulations represent descriptive, formalized, and sharable understandings of a system. They can represent a system's concept of operation, architecture, and its ability to support its intended mission. However, by focusing effort to enable such preliminary system capabilities to move through a fast acquisition life cycle, the goal is to establish and validate consensus on whether current models and simulations of the software system's components or architecture address specific system requirements. In addition, the goal is to determine whether other underdeveloped or unrecognized system requirements have emerged that must be addressed in subsequent acquisition and development cycles. As such, the goal here is more closely aligned with the idea of incrementally growing and evolving the target system in a more organic and adaptive manner.

Our first take on the requirements for how this might work can be outlined as follows:

- Acquisition participants should be able to architect, construct, assemble, execute, and analyze automated models of the overall software system capability for acquisition.

- Component models should represent elements of target environment (including people), information system infrastructure, informational products, and development, operation, and post-deployment processes.

- The initial modeling and simulation of these elements should represent the first pass through the system's requirements generation and development cycle.

- Participants should be able to iteratively refine and incrementally evolve the system model test-bed from previous steps. Then they should be able to selectively replace component models with simulated, prototype, or actual component elements.

- Participants should be able to iteratively refine and evolve intermediate hybrid system test-beds and progressively replace remaining component models with simulations, prototypes, or actual component elements. This helps to insure that a full-scale test-bed is developed, operational, and ready for post research and development deployment or transition into commercial use.

Subsequently, we can take this outline of requirements for what we envision and reformulate it into a first-cut prescriptive process, which we call the VISTA Approach.

The VISTA Approach

At this point, we outline a series of steps that articulate how software system acquisition and development become intertwined during virtual system acquisition processes. As modeling and simulation drive most of these steps, we first describe what types of models are necessary. We will also characterize what these models may look like, and how they could be represented. Then we will briefly describe how these models and simulations would be incrementally replaced when evolving the system.

Modeling and Simulation in VISTA

For this discussion, we assume the envisioned system is within the scope of available software system product families at hand. If not, then a domain analysis leading to the construction and refinement of an appropriate meta-model will be needed. Product families and their associated "smart" product models (SC-21, 1997), documents, development processes, tools, and organizational agents are defined and represented using meta-models. Detailed examples of their use can be found elsewhere (Mi and Scacchi, 1990, Mi and Scacchi, 1996, Scacchi and Mi, 1997). We then begin with the elicitation and modeling of a virtual system model (VSM) for the system to be acquired.

The VSM is a composite model—a model composed from other models. At least three types of models are needed to characterize a complex software system. One class of models is needed to represent the functional operation and data required for information processing by the system. We will call models of this type information element models (IEMs). Once an IEM is replaced with an operational system component, it becomes an information element (IE). IEMs are used to model the structure, behavior,

and performance (estimated, measured, or required) of the computing hardware and software that inputs, processes, and outputs system data. A second class of models is needed to depict the functional behavior of the IEs embedded within a man-machine system (e.g., command and control system, theater air dominance system, mission support system, etc. in Figure 3) to be acquired and built. We call these system element models (SEMs), and when replaced, system elements (SEs). The third class is needed to represent the "system of systems," sensors, and environmental context in which the embedded man-machine systems operate. These are called environment element models (EEMs), and when replaced, environment elements (EEs).

"Each type of model requires a computational mechanism that can support model entry and definition, interpretation, simulation, and animated visualization."

Each type of model requires a computational mechanism that can support model entry and definition, interpretation, simulation, and animated visualization. Commercially available discrete-event simulation packages represent one such mechanism. These packages are well suited for simulating models that are represented as queuing networks whose arrival queues and service rates are specified according to statistical or algebraic models.

Different types of models may require different kinds of simulation; thus different tools may be needed. For example, modeling and simulating the "look and feel" and event-based operation of a graphic user interface for a Military Support Training System may employ multimedia authoring or navigation tools. Commercially available tools such as Macromedia Director, Microsoft Powerpoint, or even Web browsers accessing virtual reality content across an intranet can be used for this purpose. Rapid application development (RAD) tools (Visual Basic, PowerBuilder, Visual Cafe for Java, etc.) and expert system shells (e.g., M.4 from Teknowledge) that support software prototyping or visual programming with persistent databases can enable the modeling and simulation of complex, rule-based, state-transition software applications. These are tools for developing virtual prototypes of IEs (Garcia, Gocke, and Johnson, 1994). With these tools, it is possible to model, simulate, or approximate the behavior of software applications using stubbed, canned, or pre-calculated input and output data values as place holders for complex calculations required of an eventual software system implementation. As such, modeling and simulating a VSM may benefit from use of a computing environment where multiple types of models and simulations can be defined, composed, simulated, and displayed. Furthermore, it may be desirable for such an environment to be accessible over the Internet to facilitate the sharing, discussion, and review of modeling and simulation efforts among the different organizational representatives participating in a program acquisition.

IEMs can be modeled in a variety of ways. A common tactic may be to depict IEMs as hierarchically decomposed black boxes (closed systems), white boxes (open systems), or gray boxes (closed systems with limited internal visibility). These boxes are placeholders for hardware or

software system modules that are to be acquired and developed. Each box can represent a computation unit that can receive inputs or event signals, perform some calculation, then produce some outputs, state transition, or some new event. They can be modeled and simulated using any of the tools noted above. However, depending on the kind of acquisition concern we wish to address, particular tool choices may be most appropriate. For example, in SC–21-class ships, it may initially be an open question as to what level of computer performance is required to satisfactorily operate mission support software systems. A desktop personal computer is probably inadequate, while a large mainframe may be too much, too large, or too expensive. Thus, it seems appropriate to consider modeling the required computing hardware as a computational module with mid-range performance or processing throughput (i.e., 10–100 transactions per second) as a starting point. Further, since determining system performance throughput under different mission support workloads or traffic volume is necessary, then a discrete-event simulation package may be best to use.

However, the software system modules required to operate on this anticipated hardware may or may not be so readily understood. If we initially have little knowledge of what calculations or information is required in processing mission support data, then the software's model may simply equate to that of a module that produces a stream of input and output data transactions, say in the range of 0–8 transactions per second. Alternatively, as knowledge increases, software modules may be identified that perform different functions.

It should be possible to evaluate alternative architectural configurations or compositions of software modules as a way to understand whether system performance parameters are sensitive to the alternatives.

For example, in a mission support combat training system, one could separate user input capture and verification, calculation and database update, and output to user display as three distinct software modules. Should these modules be configured in as a linear sequence, a fully interconnected concurrent network, or bundled together as a single large module? Which alternative configuration would be easiest to build and test? Which would have the best performance? Which would cost the least? Perhaps we could guess the answer(s). However, if we can model, simulate, and collaboratively discuss the three architectural alternatives, then we can begin to articulate a basis that leads to a consensus answer that can be backed up with evaluated alternatives and simulation results.

"It should be possible to evaluate alternative architectural configurations or compositions of software modules as a way to understand whether system performance parameters are sensitive to the alternatives."

Would the consensus results from such a modeling and simulation exercise be more believable than someone's best guess? In lieu of some controlled experiment, the answer to that is subjective. However, the modeling and simulation results would be explicit, repeatable, and subject to tradeoff analysis and consensus validation. In addition, these results can be open to challenge and reformation

in a manner that may be more tractable than someone's best guess. Nonetheless, if someone such as a software architect experienced in the design of mission support combat training systems can argue persuasively about his or her best guess, then this alternative could be represented in an IEM, simulated, compared and validated.

SEMs provide the ability to embed software systems within man-machine systems settings. SEMs embed IEMs or IEs in a user-driven input and output environment. Users create inputs in response to their work assignments, and to information output from the system and displayed to them. For example, when using a training system, users may select among "menu items" or enter system commands. This may cause the training system to process their input, provide an updated user interface display, then wait for the user's next input action. As such, SEMs must model user behavior in driving and responding to system actions or events, as well as model system behavior in response to user actions.

"...users can only provide either acceptable input, acceptable but erroneous input that is detected, or unacceptable input."

While user behavior is open-ended, only a range of possible user-system interactions will be modeled. For example, users can only provide either acceptable input, acceptable but erroneous input that is detected, or unacceptable input. SEM simulation may include the use of software "drivers" that cause the arrival of user input or input events, together with system responses or service time intervals that follow statistical formulas or some other characterization function. SEM simulation can then be supported using common discrete-event simulation tools if user behavior is being simulated. Alternatively, if the system's behavior is being simulated for real users, then multimedia or RAD tools may be used to provide simulated user interfaces for real users to evaluate. As with the IEM simulations, the plausibility and consensus validation process noted above will also apply here.

EEMs provide the ability to embed the man-machine system in its overall environmental context. For example, weapons control systems may be designed to use various sensors (radar, sonar, satellites, etc.) to zero in on their targets. These sensors may themselves be complex systems. Similarly, weapons control systems will interact with many other shipboard systems, including those for mission support, and command and control. These systems must act in concert to realize the overall effectiveness of a complex system of systems that a ship of the SC–21 class represents. Therefore, EEMs must model the interoperation and integration of multiple systems. This may entail modeling the overall patterns of data or messaging traffic between systems, as well as between systems and users as a group.

Alternatively, in response to different scenarios for total system engagement, the EEMs may be used to model the ebb and flow of information across the system of systems. With this, we expect that the patterns of information flow on a SC–21 ship in response to a hostile attack scenario will be different than the flows associated with routine ship operations and maintenance scenario. Subsequently, these information traffic or flow patterns can be modeled

and simulated using discrete-event simulation capabilities, and the validation process described earlier again applies here.

Overall, the remaining challenge is to integrate and interoperate the different models, simulations, and elements. This is the purpose of a collaborative test-bed such as a Battleship Lab for SC–21 class ships (Cothran, 1996; Kouzes, Meyers, and Wulf, 1996; Wilson, 1996). It may serve to support the integration and interopera-tion of multiple, mixed mode models and simulation tools, as well as of multiple system elements with many models and simulations. At this time, developing such a test-bed may be an expensive but nonetheless necessary proposition. However, even if the cost of such test-beds approaches 5-10 percent of system development costs, such an investment may be reasonable given that the total overall effectiveness of the system platform is long-lived, software-intensive, and thus software-dependent.

Again, our objective is to find ways to facilitate the articulation and elaboration of requirements, risks, and cost-drivers for complex, software-intensive systems. It also assists those involved in system acquisition to understand how modeling and simulation tools and techniques can be used. As such, we now provide a brief description of how incremental system acquisition and development would replace the system models with operational elements and system components.

Incremental Replacement of System Models with Operational System Components

Given that we have outlined the overall VISTA approach for modeling and simulation, we can describe how this approach could work in the context of acquiring a software system. We examine software systems for SC–21 class ships, although we limit our discussion to a representative subset of software systems for these ships. We use mission support systems in our discussion. Accordingly, we describe how the information, system, and environment elements for mission support are incrementally acquired and developed in a series of spiraling iterations following the approach. We show how these elements can change while progressing from models to actual software system architectures. Similarly, we identify what difference it makes to improve the acquisition of software.

"Again, our objective is to find ways to facilitate the articulation and elaboration of requirements, risks, and cost-drivers for complex, software-intensive systems."

The VISTA approach begins with the acquisition of a virtual system model for mission support. A team of participants from the program office, acquisition directorate, user representatives, and prospective contractors may specify the VSM. The team might employ a wide-area collaboratory environment to share and record information giving rise to the VSM. However, perhaps only the contractors would be tasked with the modeling development activity.

The VSM can be subjected to analysis, simulation, redesign, visualization, and walk-through. Figure 4 provides a concept diagram for how this might appear if we focus on an architectural configuration of IEMs (the computer or software

elements), SEMs (the physical or human elements), and the EEMs (the external stimuli outside the system boundary). As shown in Figures 4 through 6, multiple IEMs, SEMs, and EEMs are used. This reflects the notion that the scope and depth of different models may be limited, compartmentalized, or may be divided among different organization contractors, sub-contractors, program office, etc.).

In acquiring an initial VSM for mission support systems, many kinds of models are used. For example, IEMs designate computer hardware and software subsystems. SEMs denote operational readiness test system, combat training system, and display system. Also, EEMs are needed for other shipboard systems (e.g., command and control system), sensors, and environment factors (weather, combat versus routine operations, etc.). Emphasis in developing the initial VSM is on deciding what kinds of modeling and simulation tools to use for the different types of model elements. Also, emphasis

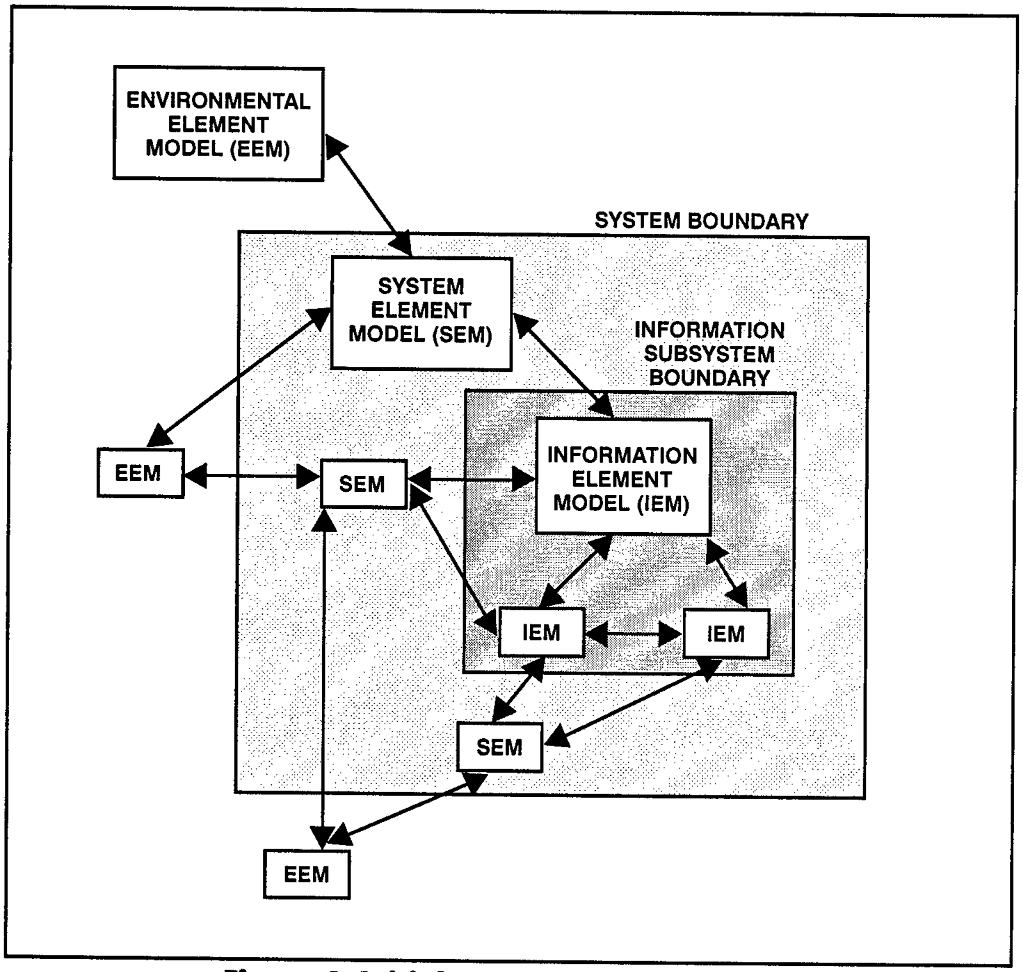


Figure 4. Initial VSM Development Cycle

is directed at how to integrate the modeled elements into an architectural configuration so that the simulated elements can interoperate. This is shown in Figure 4. Subsequently, if all VSM element models can be satisfactorily simulated at this point using a discrete-event simulation package, then the integration and interoperation challenges are reduced or eliminated.

Given that the VSM can be developed, we need to exercise and test it to explore the proposed system's ability to satisfy the requirements of its customers, users, development contractors, program managers, and others. Similarly, we need to explore the tradeoff among desired system functional capabilities, performance objectives, and costs. A wide-area software requirement negotiation and collaboration environment, such as the Win-Win environment developed at USC (Boehm et al., 1995), could be used for this purpose.

Collaboration environments, like Win-Win, enable various system acquisition and development participants to discuss the relative merits of the VSM, its ability to identify or demonstrate system requirements, and to determine and validate where there is consensus in these areas. For example, user representatives may believe that response time to user input commands should not be more than one second. The contractors may note that while such system performance may be essential for the combat training system, it may not be needed by the operational readiness test system. Thus, it would be unnecessarily costly to the program to make it so.

To help clarify their position, the contractors input the two alternative system performance requirements into the computer hardware IEM simulation. Executing the simulation using the two performance measures may produce interesting comparative results. For instance, if users of the operational readiness test system can accept a four-second response time, the required computer hardware performance can be realized at an appreciably lower cost, perhaps saving millions of dollars (Boehm and Scacchi, 1996). With this result at hand, the team agrees to revise the requirements for this information element. As such, the VSM is revised and calibrated to use this information. This helps to illustrate the how iterative analysis, simulation, performance monitoring, and benchmarking can improve understanding system requirements, and how to identify areas where virtual system acquisition efforts can reduce costs.

"...we need to explore the tradeoff among desired system functional capabilities, performance objectives, and costs."

In a later acquisition and development cycle, the team decides to assemble particular element components using fully operational and architecturally configured subassemblies. Here, the contractors must replace the corresponding model or simulation elements with operational prototypes or actual operating elements. Figure 5 provides a diagram for how this hybrid system and hybrid test-bed might appear. For example, an EEM for sonar and radar sensors may be replaced with a test-bed instrument that can generate realistic sensor input data. The display system for mission support may now be fully operational, and the computer hardware that supports the display system may be operational. Accordingly, the display

system SEM can be replaced with the operational display system SE, and the computer hardware IEM can be replace with its corresponding IE. Nonetheless, even with these virtual system elements replaced with operational components, the overall VSM test-bed can still be accessed and evaluated using a collaborative wide-area environment for requirements negotiation and validation (Boehm et al., 1995, Kouzes, Meyers, and Wulf, 1996).

Once operational components are integrated into the VSM, it becomes possible to more systematically walk through, exercise, monitor, record, and replay the revised VSM hybrid tested. This can help to validate choices, explore further tradeoffs, and articulate systemic bottlenecks or processing failures in the system's architecture (Scacchi and Mi, 1997). For example, while evaluating the operational performance of the display system that interacts with the combat training system, it appears to users that important information of the user display is being updated too fast for users to act

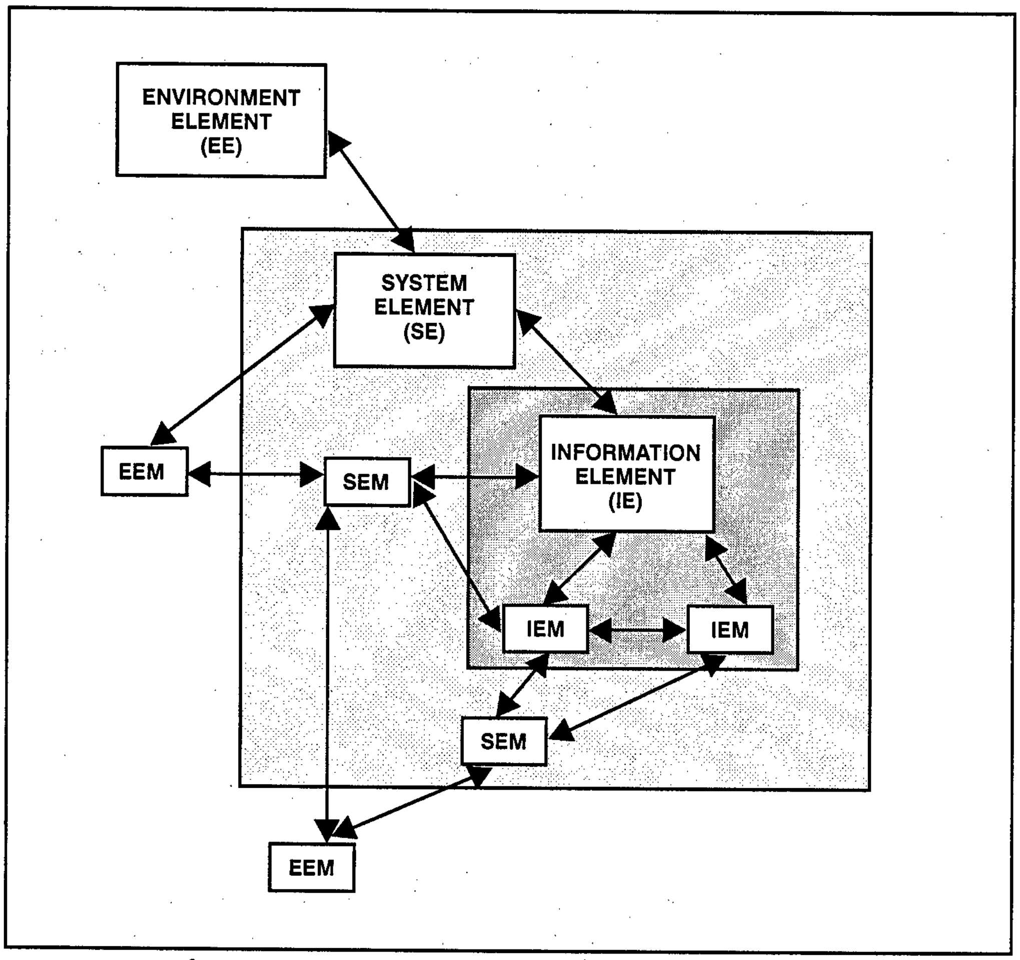


Figure 5. Intermediate VSM Development Cycle

appropriately. Instead, the rate of information display needs to be slowed, or the information content needs to be aggregated and summarized. Thus, from the user standpoint, the current system operation in the VSM is risky or not feasible. As before, system element parameters need to be adjusted, otherwise alternative system architectures need to be considered and evaluated.

With an intermediate VSM, further elaboration is needed to field a deployable system (see Figure 2). If this is the case, then the acquisition and development team must revisit the selection of software and system components to develop. Otherwise, they can perform partly simulated operational test and evaluation, then experimentally field the system either across a wide-area intranet test-bed (Scacchi and Noll, 1997), or in a battleship lab test-bed, in order to continue to calibrate and refine the VSM for further post deployment studies. Thus, here we seek to illustrate how virtual system acquisition can help identify potential risks and attendant cost drivers that may not be manifest until field operation stages of the system's overall life cycle.

When further system capabilities are needed, the participants can exercise the VSM. This means they may adjust simulation parameters, have users test-drive and evaluate system prototypes, etc., to determine tradeoffs and validate priorities through consensus. Consequently, they may choose to revisit the selection of components to acquire and develop. Jumping ahead, the acquisition and development participants can continue to evolve and continuously improve the emerging system architecture. This requires a revisit through the preceding steps until all remaining system component simulations or prototypes are replaced by their operational counterparts. Figure 6 provides a diagram for how this late stage system architecture might now appear.

Here we see that all of the system and information element models have been replaced with their operational elements. Some EEMs remain, however, since they may designate other major shipboard system undergoing concurrent development. Thus, while the sensor test-bed may be operational and integrated to interoperate with the mission support systems, the command and control system as well as other major systems may not yet be operational and available for integration. But these other systems must still conform to their EEMs placeholders for use with the mission support system. Subsequently, an additional capability is required for characterizing or extracting an updated EEM from this VSM. This updated information needs to be used in other VSMs corresponding to environment elements that constitute the system of systems. From a technical standpoint, this requires addressing problems in system component interface definition, and in managing concurrent access to different versions of these components or model placeholders. From an organizational standpoint, failing to coordinate access and propagation of component interface definitions or changes is a common problem that precipitates

"Once operational components are integrated into the VSM, it becomes possible to more systematically walk through, exercise, monitor, record, and replay the revised VSM hybrid tested."

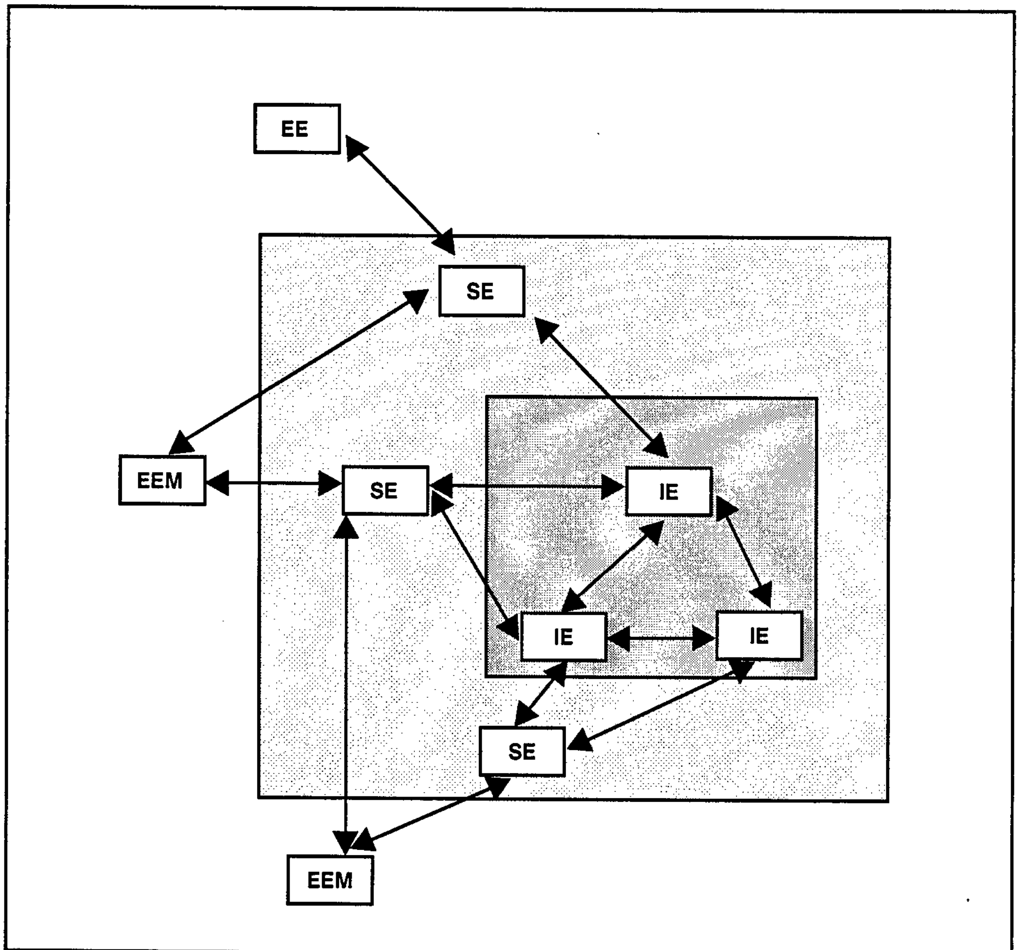


Figure 6. Final VSM Development Cycle

difficulty in systems integration and interoperability. Knowing where problems lie, and being able to prevent or circumvent them through virtual system acquisition, provides another capability for reducing risks and costs associated with the development of software-intensive systems.

Finally, throughout the overall VISTA process we have just outlined, current best practices in software program management (SPMN, 1997) and a consensus recommendation from the Blue Ribbon Panels (Boehm and Scacchi, 1996) point to the opportunity to track and manage software feasibility and risk using new program management support tools. Figure 7 provides a view of the user interface "dashboard" to such a tool, as well as suggesting how program management information may be conveyed.

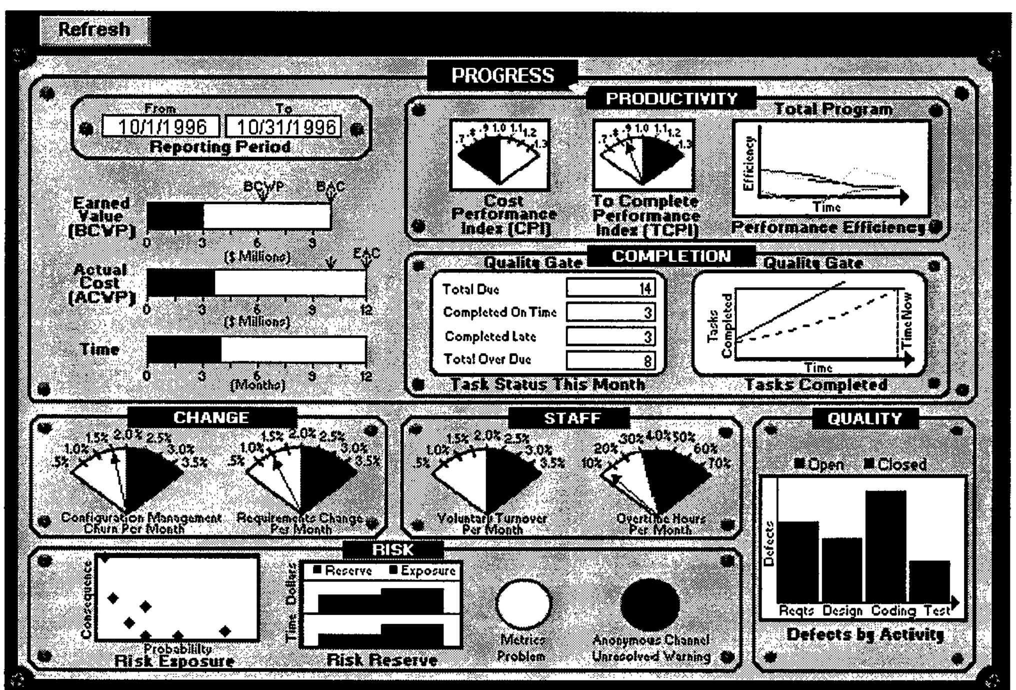
Participants in a virtual system acquisition also need to track, organize, record, and store records of the steps they took. Furthermore, they may need to document what transpired, how, by whom, why, and with what outcomes. These records and

documents represent important knowledge assets emerging from the acquisition effort. Capturing and organizing this information is often cumbersome and haphazard. However, we find that these knowledge assets can be easily captured and linked to the virtual system models and elements using hypertext mechanisms commonly available in information sharing and requirement negotiation support environments (Noll and Scacchi, 1991, Boehm, et al., 1995), rather than being cast as a mountain of paper.

With this basis for VISTA approach, we can now put forward a matrix of the transitional steps for how to realize the technical basis for supporting VISTA. This is then followed by a description of the organizational transitions for VISTA.

Mapping the Technological Transitions to VISTA

Although the VISTA-based approach may be a radical departure from traditional system acquisition practice, getting there may be best achieved in an evolutionary manner. To be clear, the VISTA approach is new, but the tools, techniques, and concepts it involves—incremental acquisition and development, virtual prototyping, wide-area collaboratories, software requirements negotiation and validation environments, etc.—are beginning to be used in system acquisition efforts. Thus, as VISTA implies the need to use an automated support environment for modeling, simulation, and program management, the



Source: SPMN, 1997

Figure 7. A Program Management Dashboard for Assessing Software Development Progress

required tools and techniques for such an environment can be investigated, refined, and deployed in a multistaged manner. An integrated information management environment to support the acquisition and development of complex software systems, such as those for the SC–21 program, is not yet available. However, such an environment can be constructed and put into use following the road map outlined below and elsewhere (Boehm and Scacchi, 1996). The resulting environment can then be positioned to support large system acquisition programs.

We can explain the technological basis to support the transition to VISTA in terms that cover its anticipated use in acquisition, (its technology, and the research needed to realize its technology and usage. At the same time, we can characterize how each of these three aspects correspond to the software system development life cycle stages that include system concept definition, architecture definition, and ongoing spiral development. Together, we can associate each of these into a matrix that organizes the VISTA research, technology, and acquisition usage as shown in Table 1.

"To be clear, the VISTA approach is new, but the tools, techniques, and concepts it involves... are beginning to be used in system acquisition efforts."

Moving from top to bottom, right to left, we can outline the associated operational concepts for VISTA, thereby characterizing the technological transitions "from ends to means."

- Concept feasibility determination: Given a new mission or strategic objective, determine whether appropriate technology, architectures, and resources can be feasibly brought together into a new software-intensive system in an affordable and timely manner.

- Architecture feasibility determination: Given a proposed software system architecture, determine whether it can satisfy mission or strategic objectives in an affordable and timely manner.

- Virtual system acquisition: Given a feasible system concept and architecture, acquire the proposed architecture as a series of modeled, simulated, or implemented subsystems. These subsystems can be developed by progressively replacing or transforming the modeled or simulated subsystems with prototyped or real implementations.

- VISTA-1, top-level feasibility advisor, parametric models: A top-level feasibility analysis-modeling environment is needed for checking established acquisition heuristics and parameters. Such an environment could be used to determine whether the candidate technologies, architectures, and resources can be brought together to address a new mission or strategic objectives. This environment would represent the first version of the VISTA support environment (VISTA-1). The environment proposed by the software program managers network (Figure 7), together with software cost estimation tools, software requirements negotiation capabilities, and access to a collection of software feasibility heuristics are available today for

Table 1. VISTA Research, Technology, and Usage Context

		TECHNOLOGY MATURITY		
		Research	**Technology Usage**	**Acquisition**
SOFTWARE/SYSTEM LIFE-CYCLE STAGES	**Concept Definition**	Software feasibility heuristics	VISTA-1: Top-level feasibility advisor, parametric models	Concept feasibility determination
	Architecture Definition	Architecture representation and analysis M&S, advanced cost/schedule/ quality M&S	VISTA-2: Models and simulations of subsystems and elements	Architecture feasibility determination
	Spiral Development	Integration into commercial SDEs	VISTA-3: Hybrid measurement, M&S environment	Virtual system acquisition

experimentation and initial usage (Boehm et al., 1995; STSC, 1995; SPMN, 1997).

- VISTA-2, software-intensive models and simulations: VISTA-2 is an enhanced VISTA-1 environment for software-intensive modeling and simulation. It could be used to prototype, analyze, and execute system architectural capabilities and functionality, then reconcile these performance characteristics against the cost, schedule, and quality tradeoff among proposed architectural design alternatives. VISTA-2 is used order to determine whether proposed application system architectures are viable.

- VISTA-3, hybrid measurement, modeling and simulation environment: The VISTA-3 environment is built to expand the capabilities of VISTA-2. In order to acquire incrementally developed software application systems, VISTA-3 can be used to support the cooperative modeling, simulation, and measurement of the performance capabilities of an evolving application system, its subsystems, and their collective architectural design.

- Software feasibility heuristics: We need to collect, validate, and refine a knowledge base of "best practice" heuristics for software system acquisition, architecture, and overall development.

This knowledge could provide plausible advice for how to assess the top-level feasibility of an emerging software application system. These heuristics can help determine what matters, and which technology, architecture, or resource characteristics affect the overall feasibility of the system (Rechtin, 1991; STSC, 1995; SPMN, 1997).

- Architecture representation and analysis modeling and simulation (M&S), and advanced cost, schedule, and quality M&S: We need to research and develop new architectural representations that support incremental building and evolving large application systems using models or simulations. These representations also must be able to incorporate the architectures of its subsystems, whether as already implemented or newly developed components. We further need to be able to represent the cost, schedule, and quality associated with the development of different software components or architectural configurations.

"We need to collect, validate, and refine a knowledge base of best practice heuristics for software system acquisition, architecture, and overall development."

- Integration into commercial software development environments (SDEs): In order for VISTA tools to be broadly applied across the spectrum of DoD or other large-scale system acquisitions, they need to become available as extensions (e.g., "plug-ins" or "helper applications") to commercially available software engineering environments.

With this context for VISTA research, technology, and acquisition usage in mind, we can now more simply characterize the overall concept for how VISTA might be employed. This can be outlined in four steps:

- Pre-proposal requirements analysis: Use the VISTA environment to analyze feasibility of the system's concept and mission requirements (a sanity check on the technical perspective for a new mission program to determine rough order of magnitude for cost, architecture, other risk items, etc.) prior to the Request For Proposal.

- Proposal analysis: Upon receipt of development contractors' proposals, use VISTA to analyze each proposal for feasibility, determine which proposals are in competitive range, and what assistance is needed to evaluate the technical perspective (e.g., architecture) of those proposals within competitive range.

- Project startup: Use VISTA to evaluate the feasibility of resources (cost, people, etc.) and schedule of proposed system design. This could also be used for "fly-off" scenarios as well, when competing designs are being evaluated.

- Ongoing program review: Use VISTA to re-analyze feasibility at progress milestones during development life cycle, as well as when significant program or system requirements changes occur.

VISTA should be applicable to product-line software system architectures, as well as to unique non-product-line software systems. It appears that the VISTA may be more readily suited to product-line software system architectures, since their recurring development can accommodate the collection, refinement, and calibration of the VISTA for the product line's application domain. However, it may also be useful for (portions of) non-product-line software, especially where a well-conceived reference model standard, such as the Air Force's Horizon Architecture, defines the software. Nonetheless, within the domains of C4I, air traffic control, management information systems, and other applications, we may expect future systems to be more likely to conform to product-line architectures. Industry trends and corporate strategies may then lead system development contractors to focus their expertise and core competencies around the mastery of product lines, rather than individual products or contracts.

MANAGING THE ORGANIZATIONAL TRANSITIONS TO VISTA

The move to adopt, implement, make routine, and replicate the VISTA approach seems to be a radical departure from current system acquisition practices and processes. While we believe that a compelling technical argument can be made for the VISTA approach, we must also address the kinds of organizational situations or changes that must be part of the transition to VISTA.

Personnel will be unfamiliar with VISTA and what is required to reengineer the processes they enact during system acquisition. Mutually respected collaborative education, elicitation, and information sharing among the participating user, development contractor, and program management organizations will be required. WWW-based collaborative work environments or acquisition collaboratories (Kouzes, Meyers, and Wulf, 1996) can help provide the information infrastructure needed to support this. But participation and engagement in reengineering system acquisition, development, and program management must span all levels of the organization chart, and must achieve commitment, resources, and strategic attention from executive and senior management in order to increase the likelihood of success (Bashein, Markus, and Riley, 1994).

Our characterization of "as-is" system acquisition processes and practices, as well as "to-be" VISTA based approaches are understated. Clearly, there is far more detail to system acquisition or virtual system acquisition processes and practices than can be described here. Furthermore, we recognize that both "as-is" and "to-be" approaches to system acquisition are put into practice in different ways, in different organizational settings, for different system acquisitions. Capturing, understanding, and describing these variations requires systematic research, empirical investigation, and wide-area dissemination. However, experience has shown that this attention to detail can lead to

> **"The move to adopt, implement, make routine, and replicate the VISTA approach seems to be a radical departure from current system acquisition practices and processes."**

distinguishing what's common from what's circumstantial. Such detail will help surface specific actions to take to successfully engage personnel to collaborative identify and perform the organizational transformations needed to transition from the "as-is" to the "to-be."

Next, as the world moves towards a globally networked information infrastructure based on the Internet and WWW, we recognize that the information systems and computer-based tools supporting the acquisition, development, and program management will increasingly become heterogeneous relative to one another (Noll and Scacchi, 1991; Scacchi and Noll, 1997). Interoperability will not be easily achieved without the experience and expertise needed to make it happen. However, new information technologies are rapidly emerging that will give rise to new ways to more rapidly configure, interconnect, and integrate software systems in order to enable them to interoperate. Furthermore, what's likely to be critical during early VISTA-based acquisition and development cycles is realizing interoperability at the organizational process level, rather than only at the traditional system function level. Experience shows that addressing and resolving interoperability between distinct organizations, such as those participating in a system acquisition, can often lead to ways to obviate, minimize, or avoid system function interoperability dependencies (STSC, 1995). This helps to refine, streamline, and focus both system architecture and system development processes.

"Next, as the world moves towards a globally networked information infrastructure based on the Internet and WWW, we recognize that the information systems and computer-based tools supporting the acquisition, development, and program management will increasingly become heterogeneous relative to one another."

Last, as indicated earlier, attention in this article is directed at emphasizing the re-tooling and reengineering system acquisition processes and system feasibility assessment. However, a greater payoff can potentially result from complementary incorporation of process reengineering concepts, techniques, and tools into VISTA approaches (Nissen, 1997; Scacchi and Mi, 1997; Scacchi and Noll, 1997; Scacchi, et al., 1997). For example, recent efforts to redesign acquisition and procurement processes for the Navy have identified a number of ways these processes can be transformed and streamlined to realize substantial reduction in cycle times and administrative costs (Nissen, 1997; Scacchi, et al., 1997). But these capabilities have not been used to support the acquisition of large software systems and thus require further investigation. Nonetheless, the vision of a 21st century "digital government" raises such matters for systematic acquisition research and empirical investigation befitting a grand challenge to the academic, industrial, and government research community (Schorr and Stolfo, 1997). Subsequently, the acquisition community needs to stimulate research that can find new ways to radically streamline program operations, reduce system costs, and improve service quality through reengineering, reinvention, and systematic utilization of emerging information technologies and infrastructures.

CONCLUSIONS

We have identified opportunities for research and application of modeling, simulation, and evolutionary development technologies to re-tooling and reengineering system acquisition processes. These tools and techniques can help to analyze overall feasibility and risks at various points in the system acquisition life cycle. Such a capability offers the potential to reduce software system acquisition risks and avoidable costs, as well as explore alternative system options in order to develop more affordable, capable, and flexible systems. Subsequently, we use the new SC–21 battleship program as a case study to help illustrate and explain how virtual system acquisition can work.

We put forward a vision and approach for how to rethink the manner in which software-intensive systems can be acquired across the acquisition life cycle. Central to this vision is a new approach to virtual system acquisition we call VISTA. We believe that VISTA offers a new strategy for how to address, resolve, or mitigate the recurring problems that accompanies complex system acquisition. Major program acquisitions such as the SC–21 class of ships, the Joint Strike Fighter, and others are positioned to take advantage of timely investment and adoption of VISTA strategies and support environments.

VISTA is a new approach to the acquisition of software-intensive systems. It seeks to build on knowledge of best practices in "as-is" acquisition and development processes, as well as moving toward a re-tooled and reengineered "to-be" software systems acquisition and development process. The acquisition of complex systems such as the SC–21 class of ships will use virtual prototyping and manufacturing tools to acquire and build virtual ships using collaborative wide-area computer-based environments. However, modeling and simulation tools and techniques have not yet been proposed to support the acquisition and development of the software systems needed to make the overall ship system operational and effective. Thus, we propose to fill this gap with the VISTA approach.

> **"[VISTA] seeks to build on knowledge of best practices in "as-is" acquisition and development processes, as well as moving toward a re-tooled and reengineered "to-be" software systems acquisition and development process."**

We believe that tools, techniques, and concepts embodied in the VISTA approach merit consideration and application in forthcoming large-scale system acquisitions. These include incremental acquisition interleaved with development, virtual prototyping, wide-area collaboratories, and software requirement negotiation and validation environments. However, it would be misleading to indicate that they are being used together in the manner we suggest. The VISTA approach needs to be experimentally applied and refined. Accordingly, a research and development technology road map was presented that lays out a path for the iterative, incremental evolution and integration of the technologies needed to support the VISTA vision. The technologies needed to support the VISTA approach need to be brought together and made accessible to different acquisition participants.

The VISTA approach we present is a vision of how the acquisition of software-intensive systems can be designed and streamlined for use in the years ahead. Major system acquisition programs such as the SC–21 battleships or Joint Strike Fighter aircraft are representative candidates for the VISTA approach. The success of programs such as these will depend in part on the successful acquisition and development of the software systems that enable these platforms to do their job. VISTA represents a substantial department from, and alternative to, present software system acquisition practices (STSC, 1995; SPMN, 1997). Nonetheless, we have cast it in a manner that shows how to incrementally transition from the technology and organizational practices that today support software system acquisition to the VISTA approach we envision.

Finally, moving to adopt and practice VISTA-based system acquisitions is not without its risks. Accordingly, we have sought to identify the technological and organizational transitions that must be researched, modeled, and simulated to help reduce the risks and improve our understanding of how to evolve system acquisition practices and support environments to help see the way to VISTA. In this sense, the VISTA approach could be demonstrated by applying it to the acquisition and development of a software system that incorporates the concepts in this paper and related reports (Boehm and Scacchi, 1996).

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THE USE OF PERFORMANCE INCENTIVES IN DOD CONTRACTING

Gregory G. Hildebrandt

Performance incentives have a long and interesting history in the Department of Defense (DoD). As a result of policy guidance, numerous contractswritten during the 1960s and 1970s based profit, in part, on objectively measured performance characteristics. Such contracts may have renewed policy relevance today because of both the change from detailed design-to-performance specifications and the implementation of Cost as an Independent Variable (CAIV). During a time of rapid technological change, performance incentives may also support the decentralized execution of a centralized planning process. In this analysis particular attention is paid to the DoD cost-effectiveness model developed during the 1960s. Using the policy prescription of this model, we examine the empirical relationship between the performance achieved by contractors and such variables as the cost sharing ratio, target cost, and target profit. Recently economists have extended this model by emphasizing the distinction between accounting profit and economic profit when contractor effort is unobservable. We argue that the government is likely to know a great deal about the contractor's effort and that contracts combining performance incentives with subjectively determined award fees may have very desirable properties. The F/A–18E/F contract is an important example of this type of incentive arrangement.

The breakup of the Soviet Union demonstrated that traditional centralized planning was not able to respond to local demand and supply conditions. There was a mismatch between economic institutions and the technological conditions of production. The lack of an adequate incentive system in Soviet central planning made it ill-equipped to deal with the variegated information requirements of a modern industrial society. The problems faced during the acquisition process are similar. The information requirements to directly plan performance outcomes are daunting. This is particularly true as the United States continues to lead the microprocessor-based revolution in military affairs, in which sensors, communications, and precision weapons are changing the speed and effectiveness of military operations. Clearly, to manage development during a period of radical

change with localized information, we must have acquisition policies that permit centralized planning with decentralized execution.

Weapon system development, particularly engineering and manufacturing development (EMD), is one of the most demanding "management of change" environments. In this environment, the traditional issues of central planning, particularly those associated with the relationship between technology, information, and economic institutions, are faced. To what extent should the government micromanage the activities of contractors by direct involvement in detailed decision making during engineering development? Are there incentive structures that can guide contractors' decision making toward the development of weapons systems that achieve the objectives of the government and exploit the contractor's knowledge of the detailed cost versus performance tradeoffs?

In this analysis, we discuss why performance incentives, that is, a profit function based on the performance level achieved by the contractor, may help effectuate this requirement. Performance incentives embody the government's values with respect to enhancements in the value of performance—the government's primary area of expertise during the acquisition process. They also guide contractors to achieve these objectives by permitting contractors to make detailed tradeoff decisions that are cost effective—the contractor's primary area of expertise during development. Thus, performance incentives may help effectuate management of radical change during acquisition.

Recently, a number of economists have suggested that the efficiency of the defense procurement process could be enhanced by making use of new developments from economic theory.[1] A theme running through much of this literature is that the management of a resource allocation process must take account of the information asymmetries that exist at different organizational levels. These asymmetries are present in the contractual relationship that exists between the government and its contractors, and contractual instruments must be designed that properly deal with the distribution of information.

The government has explicitly dealt with this distribution of information issue during the acquisition process when the contractor receives a profit that varies with the objectively measurable performance characteristics of the equipment. These rewards for performance functions have been used in incentive contracts in which the defense contractor shares some proportion of the contract costs with the government. When a contract includes both cost and performance incentives, it is called a multiple incentive contract.

As is seen below, the established policy for the use of performance incentives is derived a particular view of how a

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performance change can be efficiently managed, given the structure of information. In this environment, the government is presumed to know the value of performance enhancement and the contractor knows the detailed tradeoff opportunities between cost and performance that arise during the contract.

Traditional incentive contracts with performance incentives can be contrasted with contracts in which fee is partly based on a subjective assessment of contractor behavior and performance. A contract containing this type of fee is called a cost plus award fee (CPAF) contract.

Interestingly, the Navy has recently employed an EMD contract for the F/A-18E/F that includes cost and performance incentives and also contains an award fee provision. The contractor shares a portion of the development costs in a conventional cost-plus-incentive-fee (CPIF) cost incentive. There is also a schedule incentive, in which certain funds are withheld until first flight is achieved. In addition, the contractor can receive a fee based on both objectively and subjectively determined performance. Fifty percent of this fee is based on technical performance, of which 70 percent is based on demonstrated measurable performance and 30 percent based on a subjective government assessment of technical performance. The remaining 50 percent of the award fee is based on a subjective government assessment of contractor management and logistics. The F/A–18E/F contract, therefore, combines features of a CPIF multiple incentive contract and a CPAF contract. The contract, therefore, can be described as CPIF/AF contract.[2]

As will be seen, this type of contract aids the management of change in a somewhat different dimension of the informational environment. When award fees are used, it is assumed that the government can properly assess certain aspects of contractor behavior, by the completion of the contract, that may be impossible to define at the time the contract is awarded.

There are two recent policy changes that bear on the use of performance incentives. One is the emphasis being given performance specifications rather than detailed design specifications; the second is the recent implementation of CAIV.

"Performance incentives only are practicable if there are opportunities for tradeoffs to be made during the contract."

The use of performance specifications and performance incentives are strongly interrelated. Performance incentives are practicable only if there are opportunities for tradeoffs to be made during the contract. Performance specifications combined with an Operational Requirements Document (ORD) that identifies both "threshold" and "objective" performance levels increases the number of tradeoffs that can be made. In contrast, detail design specifications may preclude many tradeoffs possibilities.[3]

CAIV expands the opportunity to make tradeoffs between performance and cost during the acquisition process. This is also consistent with the use of performance incentives, which implicitly define the tradeoffs that are desired by the government.[4]

We begin our analysis with a discussion of the history of performance incentives from the standpoint of usage and policy. Particular emphasis is given to the

approach recommended by policy directives in the 1960s. The model developed to guide policy is discussed and we describe how efficient resource allocation can be achieved using this approach. We also briefly mention attempts made to expand this model. Using a data set of the outcomes of contracts with performance incentives during the late 1960s and early 1970s, we examine the relationship between contract outcomes and key contract characteristics. Finally, we return to the use of award fees in conjunction with performance and cost incentives.

"The policy for performance incentives developed by DoD and NASA in the 1960s, and still in effect today, is based on the assumption of hidden knowledge possessed by the single contractor."

History of Performance Incentives in DoD Contracting

The government contracted for its first aircraft with the Wright Brothers in July 1909 at a target price of $25,000 and a target aircraft speed of 40 miles per hour. However, for every mile per hour over the target, the contractor would receive an additional $2,500; for every mile per hour under the target, the contractor would lose $2,500. The minimum required speed under the contract was 36 miles per hour. The speed actually achieved by the aircraft was 42 miles per hour, so that a performance incentive reward of $5,000 was received in addition to the target price of $25,000.[5]

Interest in performance incentives, however, greatly increased during the 1960s. The DoD Incentive Contracting Guide, in 1962, stated[6]:

> Perhaps no other DoD procurement policy offers greater potential rewards than the expanded use of performance incentives in developmental contracts. Properly conceived and applied, these incentives can do more than any other factor to encourage maximum technological progress under a single contractual effort.

As a result of this guidance, contracts including performance incentives were widely used by DoD during the 1960s and 1970s. In addition, in 1968 a special agency called the DoD Program Office for Evaluating and Structuring Multiple Incentive Contracts (POESMIC) was established. Shortly thereafter each military service instituted a policy in which all multiple incentive contracts over $5 million be structured with the aid of POESMIC. Within two and half years of the establishment of this office over 150 multiple incentive contracts were evaluated.[7]

The policy for performance incentives developed by DoD and NASA in the 1960s, and still in effect today, is based on the assumption of hidden knowledge possessed by the single contractor. During the 1970s, attention shifted to the determination of the optimal risk-sharing relationship between the contractor and the government. It has been established that when the performance incentive function is determined in accordance with policy, and the government doesn't know the cost relationship, the contractor's share of contract costs is the parameter that

determines the optimal risk-sharing relationship between the contractor and the government. This parameter can be shown to depend on the risk tolerance levels of the government and the contractor.[8]

However, the early discussions of optimal risk sharing focused on a problem with only hidden knowledge. The contractor is assumed to maximize accounting profit on the contract with greater knowledge of the tradeoff opportunities than the government.

In the late 1970s and during the 1980s, economists explicitly drew a distinction between economic and accounting profit by introducing the disutility of effort into the contractor's objective function. Viewing the government as the principal and the contractor as the agent, one assumes that the agent's economic profit is equal to contractual profit less the implicit cost of effort.[9]

This implicit cost equals the minimum compensation required for the contractor to put forth additional "effort" and would not be part of accounting cost. In this analysis, our interpretation of this implicit cost variable is that at any time during the contract when a particular performance level is being developed, the contractor can reduce costs by working more intensively. The effort variable, however, can also be interpreted more broadly and might represent any contractor activities that are motivated by noncontractual considerations.[10]

The presence of asymmetric information is emphasized by economists in this analysis. The models that have been developed emphasize the role of moral hazard with hidden action, and therefore assume that the contractor knows more than the government about certain key features of the development process. However, the government's information requirements to properly structure an incentive contract in this environment are quite demanding.

The contractor's effort level is assumed to represent a hidden action not observable by the government. To address this problem in the manner recommended by the economists, however, it is necessary for the government to know how this hidden action affects a contractor's economic profit.

In fact, during the 1960s there were extended discussions about such factors as effort and extra-contractual considerations. However, the incentive framework was deliberately narrowed because of the view that these factors could not be properly addressed with performance and cost incentives. The use of award fees based on a subjective assessment of effort was suggested as a way of coming to grips with factors that are difficult to define at the time the contract is specified.

"Viewing the government as the principal and the contractor as the agent, one assumes that the agent's economic profit is equal to contractual profit less the implicit cost of effort.[9]"

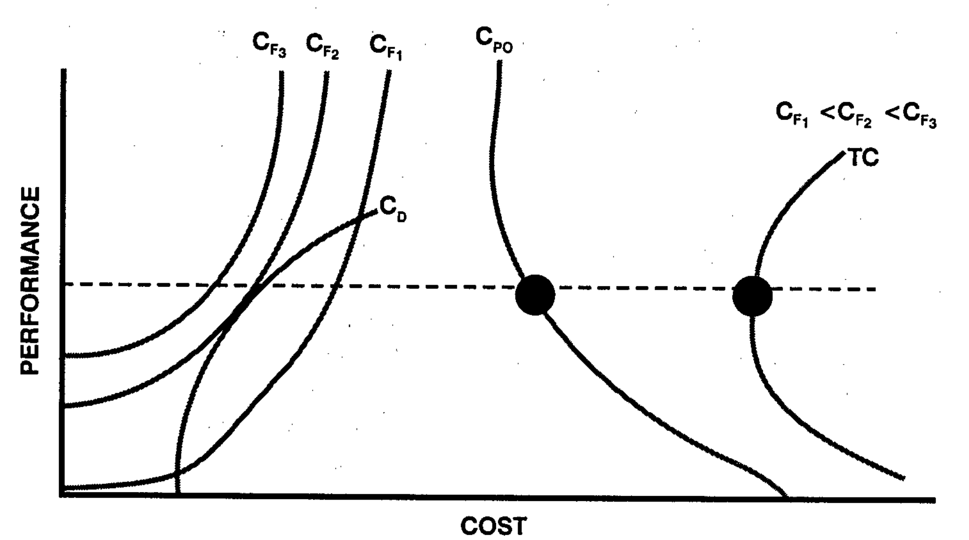
Throughout the analysis, we focus on the use of performance incentives when there is a "sole-source" procurement relationship between the government and the contractor. Bidding issues that may arise among several contractors are either inapplicable or have already been resolved in an earlier competitive procurement.

DoD Cost-Effectiveness Model

Because the arguments made in the 1960s remain valid today, we give particular emphasis in our discussion to the cost-effectiveness model developed during that period. Figure 1 displays the cost effectiveness model for a situation in which the total effectiveness of the weapon system is specified and the objective is to develop a performance level for each unit of equipment that achieves the specified total effectiveness level at minimum cost. In the figure, the performance level developed depends on the cost expenditure during development. Although one "expected" cost of development curve C_D is identified, there is uncertainty concerning the cost required to achieve any performance level.

Increases in the performance level, however, decrease the cost of procurement and operation, C_{PO}. For example, increases in reliability and maintainability decrease the quantity of weapons that must be procured to achieve the stated mission objective. Total (life cycle) cost equals the sum of the cost of development and the cost of procurement and operation: $T_C = C_D + C_{PO}$.

Several constant fee curves are indicated on the diagram (C_{F_1}, C_{F_2}, C_{F_3}). Notice in Figure 1 that as performance increases at a particular level of development cost, the contractor moves from C_{F_1} to C_{F_2} to C_{F_3} and the profit received by the contractor rises. As development cost increases at a particular performance level, the profit declines. Each constant fee curve, therefore, describes alternative combinations of cost and performance that



C_F = Constant = F (performance, cost of development)
C_D = Cost of development = F (performance)
C_{PO} = Cost of procurement and operation; future cost curves
T_C = Total cost = $C_D + C_{PO}$

Figure 1. DoD Cost-Effectiveness Incentive Model

yield the same level of fee. Because there is a certain cost increase and performance increase that yields a constant profit level, the constant fee curves communicate to the contractor how much the government is willing to spend to increase performance.

The constant fee curves are the mirror image of the C_{PO} curve. This means that the contractor is being implicitly told that it is appropriate to spend at most an amount equal to the procurement and operations cost savings to increase performance. If the contractor maximizes accounting profit, there is no conflict between this government communication and contractor motivation.

The cost-effectiveness model assumes that there is hidden knowledge possessed by the contractor. This hidden knowledge occurs because the contractor is assumed to face a nonstochastic relationship between performance, q, and C_D at the time the tradeoff decisions are made, that is not known by the government. In this situation, the reward received for enhanced performance, Δq, should equal the contractor's share of contract costs, s, times the value to the government of enhanced performance.

The amount the government is willing to pay for enhanced performance equals ΔB. Therefore, the performance incentive function, P, should be structured so that:

$$(1)\quad \Delta P/\Delta q = s\Delta B/\Delta q$$

There is a simple logic behind this performance reward. During the development process, the maximum the government is willing to let the contractor spend for enhanced performance is the value to the government of the extra performance. The government, therefore, is indifferent between such an expenditure and the status quo. To ensure that the contractor is also indifferent between spending, and not spending this amount, the reward for enhanced performance must just equal the contractor's lost profit from spending an amount equal to the value to the government of the additional performance. This lost profit from a cost expenditure is the contractor's share of development cost times the cost incurred.

Similarly, under this performance incentive function, if the cost of enhanced performance is less than the value to the government, the contractor's profit would rise; if the cost is greater than the value to the government, the contractor's profit would fall. The contractor, therefore, is motivated to make the tradeoff decisions that are in the interests of the government, even though the government does not know the cost of the performance enhancement.

"If the contractor maximizes accounting profit, there is no conflict between this government communication and contractor motivation."

Figure 2 depicts optimal decision making by the contractor when the performance incentive function is properly specified. The downward sloping curve equals the profits from incremental performance, which from Equation 1 equals the contractor's share of the benefits to the government of the incremental performance. The upward-sloping dashed line represents the contractor's share of incremental development costs when the development costs are higher than anticipated; the upward-sloping solid line to the

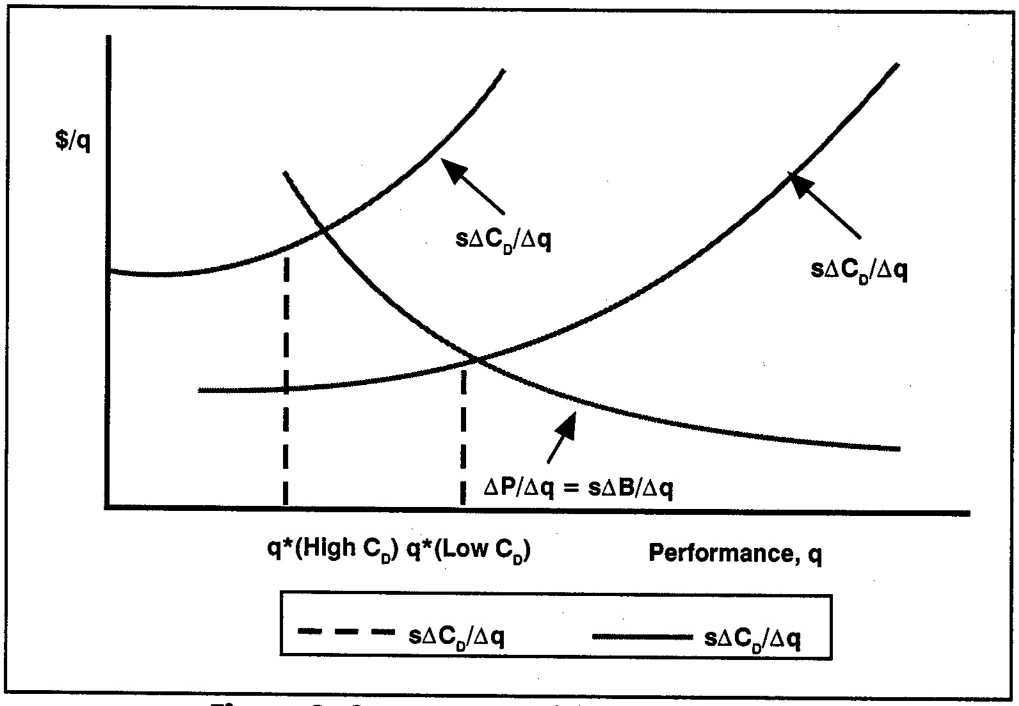


Figure 2. Contractor Decision Making with Optimal Performance Incentives

right equals the contractor's share of incremental costs when the costs are lower than anticipated.

To maximize profits on the contract, the contractor equates incremental benefits and incremental costs, $\Delta B/\Delta q = \Delta C_D/\Delta q$, as desired by the government. Therefore, performance level q* (High C_D) is selected when development costs are high and q* (Low C_D) when development costs are low. These are precisely the performance levels desired by the government in each development cost situation.

This approach to structuring performance incentives was taught in DoD-sponsored procurement courses as early as 1964.[11] In 1969, the "DoD/NASA Incentive Contracting Guide" states that this method achieves two important objectives[12]:

> first, it communicates the Government's objectives to the contractor; second, of greater significance, it establishes the contractor's profit in direct relationship to the value of combined performance in all areas.

The "DoD/NASA Incentive Contracting Guide" has never been formally superseded. In the empirical analysis we will assume that the performance incentive functions have been constructed on the basis of the guidance provided by this document.

EMPIRICAL ANALYSIS OF PERFORMANCE INCENTIVES IN DOD

Empirical analysis employs a data set developed during the years in which performance incentive contracts were used most extensively. The initial data set includes incentive contracts with performance or schedule incentives awarded from 1963 to 1972 and completed no later than 1973. There are a total of 293 contracts in the initial data set, with a total contract value of approximately $4.3 billion. However, because the policy prescription is less ambiguous for performance incentives than schedule incentives, we focus attention on only those contracts that clearly include performance incentives. Also, during this period, contracting offices were discouraged from using performance incentives with very low sharing ratios, and we restrict the data set to those contracts with a calculated contractor's share of cost, s, between .05 and 1. After imposing these restrictions, there are 140 contracts with a total value of about $1.73 billion remaining in the data set.[13]

In addition to the contractor's share and the value of performance, the data set also included the initial and revised target profits, the initial and revised target cost, and the contract type. Contract type refers to whether the contract is a CPIF or a fixed price incentive (FPI) contract.

Under the CPIF contract, there is both a ceiling and a floor on the profits dollars received. A FPI contract, in contrast, does not have a ceiling on profit, but there is a specified ceiling price that equals the contractor's maximum payment. At the cost level at which the ceiling price is reached, called the point of total assumption, the contractor shares 100 percent of the costs.[14]

Typically FPI contracts are considered riskier than CPIF contracts. The specified contractor's share of cost is typically higher than under a CPIF contract. Also, the contractor's requirement to make delivery is more firm under a FPI contract. Under a CPIF, delivery of the contractually specified items ultimately depends on the willingness of the government to continue to allocate funds to the contract. To compensate the contractor for the higher risk associated with these factors, a higher target profit is usually awarded to compensate for the risk. The effect of contract type is outside the scope of the models developed, but is a factor whose effect needs to be accounted for in the empirical analysis.

"The effect of contract type is outside the scope of the models developed, but is a factor whose effect needs to be accounted for in the empirical analysis."

Typically the revised target profit, as a percent of target cost, does not vary greatly, and may hypothetically have a small effect on performance. However, it is unclear what effect large changes in target cost have on the performance level ultimately developed. We, therefore, include the percentage change in target cost calculated, relative to the original negotiated level, in the hypothesized model. This is another variable not included in the cost-effectiveness model that must be accounted for in the empirical analysis.

The following variables are therefore included in the empirical analysis:

Y_i = Performance level developed relative to target (measured as value to government)

s_i = Contractor's calculated share of cost

π_{Ti} = Adjusted target profit

C_{Ti} = Adjusted target cost

PCT_i = Percentage change in target cost

D_i = contract type (if FPI, $D_i = 1$; if CPIF, $D_i = 0$).

We need to emphasize that the performance incentive function is assumed to be structured so that Equation 1 is satisfied. As a result, knowing the contractor's share of cost and the profit received for performance permits calculation of Y_i. When Y_i is regressed on the remaining variables, the following estimated equation is obtained (t statistics in parenthesis):

(2)

$$Y_i = \underset{}{660.70} - \underset{(-0.41)}{124.93s_i} + \underset{(3.46)}{1.89\pi_{Ti}} - \underset{(-1.57)}{0.06C_{Ti}} - \underset{(-0.62)}{3.01PCT_i} - \underset{(-2.71)}{1724.32D_i}$$

$N = 140,\ R^2 = .29$

The contractor's share of costs is not statistically significant. This is consistent with the cost-effectiveness model. Higher target profit, however, does explain significant variation in Y_i, while target cost is only marginally negatively significant. The percentage change in target cost is statistically insignificant, and the contract type is significant. The coefficient of D_i indicates that, other things equal, FPI contracts tend to be associated with lower performance.

When the variable PCT_i is deleted from the regression model and the regression equation is reestimated, one obtains:

(3)

$$Y_i = 576.99 - \underset{(-0.39)}{119.20s_i} + \underset{(3.50)}{1.91\pi_{Ti}} - \underset{(-1.62)}{0.07C_{Ti}} - \underset{(-2.68)}{1703.01D_i}$$

$N = 140,\ R^2 = .29$

For the variables retained in Equation 3, the coefficients and t-statistics are quite similar to those obtained in Equation 2.

While the DoD cost-effectiveness model predicts that the performance level selected does not depend on s_i, π_{Ti}, or C_{Ti}, both π_{Ti}, or C_{Ti} are significant in the empirical analysis. The theory, however, is silent on the effect of contract type on performance outcome. The model fails to address the proper structuring of a contract at this level of detail. Clearly, further analysis is needed to understand why π_{Ti}, C_{Ti}, and D_i are statistically significant in the empirical analysis.

Award Fees and Performance Incentives with Observable Effort

A full discussion of the models developed by economists to address asymmetric information is beyond the scope of this paper. Interestingly, even though the theoretical analysis arises from the asymmetric informational relationship that exists between the government and the contractor, there are demanding informational requirements to implement the theoretical models. In his discussion of a simple procurement problem with effort unobservable by the government, William Rogerson notes:[15]

> For normative purposes, the problem...is that the precise na-

> ture of the optimal contract is highly dependent on features of the contracting environment that the government may be unsure about. For positive purposes, the problem is that the theory does not generate testable predictions. Therefore...the major value of this model to date has been to clarify the underlying incentive issues rather than to explain specific contracting phenomena.

This suggests that the information needed to implement many of the ideas from the theoretical literature is not available. Although we will not provide a detailed summary of the theoretical developments, suffice it to say here that an important distinction is made between accounting profit, π_A, and economic profit, π. For example, it has been assumed that economic profit equals accounting profit minus the unobservable implicit cost of contractor effort:[16]

(4) $\pi = \pi_A - h(e)$.

The function, h(e), measures the implicit dollar cost of this effort to the contractor, that is, the amount the contractor must be compensated to attain various effort levels. In this analysis, contractor effort is assumed to be directed at development cost reduction. As discussed above, however, it is also possible to interpret the effort variable as representing the extra-contractual influences on government contracting. As long as there are such extra-contractual influences, it is unlikely that the contractor will only be motivated by the accounting profit received on the development contract in question. The assumption, therefore, that accounting profit on the contract in question and economic profit differ is probably valid.

However, government personnel in the program office and those who actually work at the contractor's plant actually possess a great deal of information about both the contractor's effort and the disutility of this effort. There is probably an observational horizon level below which the contractor behavior is not observable to the government. For example, the government may be unable to observe many of the micro and micro-micro tradeoffs made among performance characteristics and between performance and cost.

"...government personnel in the program office and those who actually work at the contractor's plant actually possess a great deal of information about both the contractor's effort and the disutility of this effort."

Above this horizon, however, the government may be able to assess the contractually relevant characteristics of contractor behavior to include various dimensions of the contractor's effort. We, therefore, analyze a situation in which detailed information related to tradeoffs is unobservable, but the disutility of effort is known to the government by the completion of the contract when accounting cost and performance level are known. Over the course of the contract, the government is assumed to gather sufficient information about the contractor's behavior that the compensation required to bring forth additional effort levels is known. And the contractor

knows that the government possesses this information.

Given this information structure, we consider the use of an award fee, A, in which profit depends on the government's subjective assessment of the contractor's relevant effort. The following analysis, therefore, should be viewed as a theoretical construct to understand the CPAF/IF contract used on the F/A–18E/F. The Appendix contains a detailed discussion of a model that accounts for the information likely to be possessed by the government. However, the basic logic of the appropriate incentive arrangement is straightforward.

"The contractor should receive an incremental profit for objectively measurable performance equal to the cost share times the value of enhanced performance."

With respect to the performance incentive component of the contract, Equation 1 continues to apply. The contractor should receive an incremental profit for objectively measurable performance equal to the cost share multiplied by the value of enhanced performance.

In this model, the contractor's effort is observable by the completion of the contract, and we assume that when the contractor increases the effort level, Δe, to develop a performance level, there will be a reduction in cost, ΔC. Or, what is really the opposite of the same coin, holding development cost constant increases in effort yield an increase in the performance level developed, Δq.[17]

Viewing effort from the standpoint of cost reduction, the benefit to the government resulting from the increase in effort equals $-\Delta C$. But the implicit cost borne by the contractor, Δh, is a social cost to the government. As a result, the government desires that the marginal benefits of additional effort equal the marginal cost:

$$(5)\quad -\Delta C/\Delta e = \Delta h/\Delta e.$$

The contractor is given an award fee, A, that depends on observable effort. When effort is increased by Δe, profits from the cost incentive increase by $-s\Delta C$, but there is also an implicit effort cost, Δh, borne by the contractor. The contractor chooses the optimal effort level to obtain the associated change in the award fee, ΔA, so that when this incremental gain is added to the incremental benefit from cost reduction, the sum just balances incremental effort cost. The following condition, therefore, holds for the contractor:

$$(6)\quad \Delta A/\Delta e - s\Delta C/\Delta e = \Delta h/\Delta e,$$

where $\Delta C/\Delta e$ is negative.

When the objective of the government (Equation 5) is combined with the objective of the contractor (Equation 6), the award function, A, should be specified (at the completion of the contract) so that:

$$(7)\quad \Delta A/\Delta e = (1 - s)\Delta h/\Delta e.$$

Incremental award fee should equal the government's share of the incremental cost of effort. The reason why the incremental cost of effort, $\Delta h/\Delta e$, is offset by $s\Delta h/\Delta e$ can be seen by examining Equation 6. The contractor is compensated for the reduction in cost obtained from incremental effort through the cost incentive. The remaining compensation needed

for the contractor to select the appropriate effort level is determined by Equation 7.

It has been shown, therefore, that an award fee can be used to augment a contract that also includes cost sharing and performance incentives to aid in the achievement of the objectives of the government.

Final Observations

The cost-effectiveness model of the 1960s has an appealing simplicity. Performance and cost incentives aid the efficient allocation of resources even though the contractor knows more about the tradeoffs between performance and cost than the government.

The observable effort model, which also includes an award fee, combines the simplicity of the cost-effectiveness model with the type of knowledge the government is likely to possess at the completion of the contract. It may provide a way of conceptualizing the use of award fees with multiple incentive contracts.

Federal profit policy emphasizes the need for an equitable profit to be earned by the contractor and for risks to be appropriately shared.[18] Performance incentives reward the contractor for developing a system that achieves the objectives of the government. In addition, as these performance incentives are employed with cost incentives in either a CPIF or an FPI contract, appropriate risk sharing can be obtained. Effectively, the government and the contractor share in the net benefits obtained from the system developed.

The addition of an award fee provision further aids the achievement of the government's objectives by awarding the contractor for efforts that can't be defined at the time the contract is structured. They also help guide the contractor toward contractual rather than extra-contractual activities Further analysis of the combined use of performance incentives and award fees is clearly merited. The F/A–18E/F contract provides the type of case material needed to begin this analysis.

APPENDIX

We assume that during development that economic cost equals accounting cost, C, less the implicit cost of effort, h(e). To achieve allocative efficiency, the following problem must be solved:

(A1) Maximize $W(q_T) + B(q - q_T) - C(q,e,\theta) - h(e)$, q, e

The function W represents the gross benefits received by the government from target performance level q_T. The benefit function, $B(q - q_T)$ represents the willingness of the government to pay for the difference between actual performance q and target performance. The contractor's accounting cost function, C, depends on actual performance developed, effort, and the variable, θ, which represents information known to the contractor, but not the government at the time the tradeoff decisions are made. Problem A1 has the following first-order condition, where the subscript of a function indicates the variable with which the derivative of the function is being taken:

(A2) $B_q = C_q$

(A3) $-C_e = h_e$

Equations A2 and A3 indicate that the marginal benefit of performance equals marginal cost, and the benefit from a reduction in accounting cost resulting from an additional unit of effort just equals the marginal disutility of effort.

We now add an "award fee," A, which awards the contractor at the completion of the contract for "efforts" undertaken. At the time the contract is specified, this function cannot be objectively defined. However, during the course of the contract, the government is assumed to develop a strong sense of the nature of this function. The contractor is assumed to understand how the government formulates the award fee function, and in maximizing economic profit, π, solves the following problem:

(A4)

Maximize $\pi = \pi_T + P(q - q_T) - s[C(q,e,\theta) - C_T] + A(e) - h(e)$, q, e

where s equals the contractor's share of costs. Solving this problem yields:

(A5) $P_q = sC_q$

(A6) $A_e - sC_e = h_e$.

If the government sets $P(q - q_T) = sB(q - q_T)$ as required by Equation 5, and sets $A = (1 - s)h$, as required by Equations A3 and A6, the optimal performance level q and the optimal level of effort e are achieved.[19] The efficiency conditions A2 and A3 are thereby satisfied. As a result, under the assumption that the government can observe the contractor's effort by the completion of the contract, a contractual outcome with very desirable properties is achieved.

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ENDNOTES

1. For example, see Leitzel and Tirole (1993), and Bower and Dertouzos (1994).

2. Shields (1996). CPIF/AF contracts are also employed on the Joint Standoff Weapon (JSOW) and AIM9X missile EMD contracts.

3. Kaminski (1996). For additional discussion of performance specifications, see Department of Defense (1995). With respect to the ORD, threshold is minimum required performance and objective is a more highly desired performance level.

4. See Rush (1997).

5. Cook, et al.(1967), p. 1.

6. Department of Defense (1962), p.30. Sherer (1964), p. 172.

7. Jones (1970).

8. The risk sharing problem as it relates to performance incentives was analyzed by Hildebrandt and Tyson (1979).

9. One of the clearest summaries of the modern approach to incentive contracts is contained in Kreps (1990, pp. 577–616). Extensive references of the earlier literature are provided.

10. Department of Defense and NASA (1969, pp.249–254), includes company growth, prestige, opportunity for follow-on business, and utilization of available skills and open capacity as "extra-contractual influences on government contracting." Typically, however, the DoD and NASA *Incentive Contracting Guide* implicitly assumes that the contractor is primarily motivated toward the accounting profit on the particular contract.

11. Case materials using this technique were developed by Harbridge House, Inc., in 1964. A formalization of the technique is contained in Cook et al. (1966, pp. 91-95).

12. Department of Defense and NASA (1969, p. 107). Underlining included in document.

13. The data was obtained from the Office of the Assistant Secretary of Defense, Comptroller, in December 1974.

14. For a discussion of contract types see Department of Defense and NASA (1969, pp. 3–6).

15. Rogerson (1995, p. 324).

16. See Kreps (1990).

17. If the development cost relation is of the form $C = C(q,e)$, it can also be written as a performance development relation, $q = q(C,e)$. If an uncertainty variable is introduced into the cost relationship, one can view cost and technological uncertainty as the same phenomenon.

18. The role of risk allocation in government profit policy is discussed in Cibinic and Nash (1995, Chapter 3).

19. Note that π_T can be set to achieve the appropriate target level given the expected cost, performance, and effort levels.

OPINION

THE WEAPONS ACQUISITION PROCESS
THE IMPEDIMENTS TO RADICAL REFORM

Lauren Holland

Despite three and a half decades of studies and reforms, weapons cost too much, take too long to deploy, and do not perform as expected. Why is comprehensive change so elusive? In this article, two points of view—the incentive and the pragmatic arguments—will be examined more fully in an effort to answer the question of why the weapons procurement process has remained, and may continue to remain, impervious to radical change. But there are some solutions that may help reform measures better prevail over the forces hindering change.

Students of weapons procurement continue to view the process with concern, mostly for its failure to perform in an efficient, judicious, and timely fashion and for its inability to produce weapon systems that provide optimal solutions to military problems. Despite 35 years of acquisition studies and reform initiatives, the same problems persist: Weapons cost too much, take too long to deploy, and do not perform as expected (Holland, 1997b; GAO, 1992; Hampson, 1989). Why, despite a commitment by the President, the Pentagon, and Congress to acquisition reform, has comprehensive change been elusive?

A broad collection of measures to effect sweeping, even radical, changes in the weapons acquisition process has been adopted or considered. In the past, reform efforts have focused primarily (although not exclusively) on streamlining the weapons acquisition process, improving cost-estimating practices, and changing personnel procedures to produce more qualified contracting staff. Recommendations have included eliminating needless legal encumbrances on contracting procedures; empowering program managers; establishing clear lines of authority; simplifying the source selection process; reducing technical criteria; recodifying federal laws governing procurement; employing more frequent product testing and competitive prototyping; improving the pay, training, and career options for personnel; and multiyear congressional funding.

More recently, radical changes have been suggested under the rubric of reengineering and reinvention that draw upon the new public management. In addition to recommendations for downsizing,

streamlining ("defatting"), and deregulating the Pentagon, advocates of this approach call for reinventing government with more competition, results-based budgeting, outputs evaluation, the elimination of functional specialization, process reengineer-ing, decentralized decision making, information "capture" and some privatization (Thompson and Jones, 1994; Hammer, 1990).

Despite legislative and presidential enthusiasm for radically restructuring the weapons procurement process, implementation of this new category of reforms (like its predecessors) has been disappointing. Why have the changes in the body of laws, regulations, procedures and processes failed to reshape the practices of those responsible for military hardware acquisition and the products of that process, the instruments of war and peace; and what can we predict about the actualization of the recent body of radical reforms?

One group of scholars suggests that past and even current reforms, although appropriately focused, have been and will continue to be resisted by the individuals charged with implementation authority. The resistance, the reasoning continues, is because there are few incentives for key actors in Congress, the Pentagon, and the defense industry to alter conventional patterns of behavior (ones that have served their interests) to accommodate the institutional and structural changes that reforms require, particularly the radical changes envisioned by the new public management.

A competing explanation argues instead that past and current reforms are unrealistic given certain institutional and political constraints, concentrating as they have on streamlining and deregulating the weapons acquisition process to make it more cost effective. Such reforms are inherently risky because they are incompatible with an American political system not designed to be efficient, and an American political culture committed to popular control, accountability, and equity.

In the discussion that follows, these two points of view will be examined more fully in an effort to answer why the weapons procurement process has remained, and may continue to remain, impervious to substantive change. While these two perspectives of acquisition are not exhaustive, they are compelling and provocative in their analyses. More specifically, the incentives and pragmatic arguments focus attention on the obstacles that frustrate the actualization of meaningful reform. While some of the obstacles (such as the incentives that drive behavior) are subject to modification, others (such as those attendant to the American political system) are not. This means that radical change can succeed only if it adjusts to certain political, strategic, and economic inflexibilities.

After a review of the forces that the incentive and pragmatic arguments identify as frustrating radical change in the

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Pentagon, the article concludes with some recommendations for accommodating reform measures to these forces.

The Incentive Structure

Recent assessments of the weapons acquisition process conclude that past and current reform efforts that alter or reengineer managerial, organizational, and procedural patterns ignore the incentive structure that fuels behavior (GAO, 1992; Fox, 1989-1990; Kovacic, 1990). In our political system, reforms must be implemented by groups of individuals who have a vested stake in the status quo of procurement.[1] Thus, the incentives to actualize these reforms are absent. This explains, for example, why key provisions of the Goldwater-Nichols Defense Reorganization Act of 1986 (which incorporated a number of the recommendations of the Packard Commission) have yet to be successfully put into effect despite more than a decade of effort. Even the centerpiece of the 1986 Act, the creation of a weapons procurement czar, provoked immediate resistance from the military services, resulting in Richard Godwin resigning after less than a year in office (Kovacic, 1990, pp. 84–85). During the same period, bureaucratic resistance compromised the operation of the Operational Testing and Evaluation Office, another key recommendation of the Act. A more recent example is the $150 billion shortfall in the Department of Defense's (DoD) 1995–99 Future Years Defense Program. According to advocates of the incentive argument, this shortfall demonstrates the Pentagon's persistent proclivity for overestimating budget support and underestimating procurement costs, despite a federal law prohibiting such behavior (GAO, 1992, p. 15). As further evidence, the Pentagon's Quadrennial Defense Review (QDR) (released in May 1997) is cited as an example of the military's reluctance to embrace radical changes in military strategy, force structure, procurement plans or operational concepts.

Although multiple examples of the military (and its suppliers and Congress) resisting change can be cited, the important question is what motivates or drives its pervasive reluctance to embrace seemingly important changes in the way America develops major weapon systems? In other words, what is the nature of the dynamic that compels key players to work at cross purposes with the very reforms they have publicly endorsed?

"In our political system, reforms must be implemented by groups of individuals who have a vested stake in the status quo of procurement.[1]"

In principle, the efforts to streamline and downsize the acquisition process, improve cost and schedule estimates, simplify procurement (especially contracting and financial reporting) practices, stabilize funding, encourage competition, limit concurrency, decentralize decision making, and secure better trained and paid program managers are popular measures. In practice, some of these reforms bring changes that threaten the organizational interests and stature of key players and agencies. The classic example is concurrency. While concurrency is important for

expediting the fielding of much needed military hardware, in cases of technological uncertainty, abbreviating the process can prevent errors being corrected before a weapon goes into production, causing costly modifications and delays. Despite support from public law, the Packard Commission, the Defense Management Review, DoD regulations, and at least one academic study[2] for more frequent use of a sequential management strategy (in cases of technological uncertainty), concurrency is still largely used, most recently in the development of the F–22 fighter plane. The reason is that concurrency works to the advantage of a military service by insulating a project from critical evaluation until a weapons system is in production. Since few weapons are canceled in production, this shields a preferred project from termination. There is no incentive, then, for the services to switch to a sequential management strategy, despite the fact that many programs whose development depends upon major technological innovations need extensive prototype testing to ensure that the "bugs" are worked out before design and production decisions are finalized.

"In short, actors in the drama of procurement are not reprimanded but rewarded for behavior that is adverse to the direction of much of the reform agenda...."

Similarly, there are few incentives for the services to produce accurate cost and performance estimates if doing so means losing a weapons system essential to their organizational stature and existence. As long as the services are rewarded for disingenuous behavior, then they will continue to manipulate risk assessments, cost estimates, and prototype test results. Nor are the defense industry and Congress blameless. Defense companies will continue to bid low and propose designs that promise extraordinary performance capabilities as long as this behavior wins them contracts.

Members of Congress will continue to pass well-intended reform legislation to rationalize procurement practices such as the Federal Acquisition Streamlining Act of 1994 (FASA), then vote to continue programs the Pentagon opposes for cost-benefit reasons (such as the V–22 *Osprey* aircraft and SSN–21 *Seawolf* submarine programs) if there are electoral or financial benefits in doing so. William Kovacic (1990) suggests that Congress, despite its statutory commitment to make the acquisition process more cost-effective, operates in ways that compromise efficiency because of its concern for public accountability. Similarly, the Pentagon and its suppliers are publicly committed to streamlining the procurement process but privately opposed because over-regulation actually shields them from public scrutiny.

In short, actors in the drama of procurement are not reprimanded but rewarded for behavior that is adverse to the direction of much of the reform agenda (Biery, 1992, p. 641). Contractors who underbid to win a contract and then fail to reduce costs receive bail-outs and production contracts (e.g., Lockheed and the *Cheyenne* helicopter). A military service that manipulates test results is rewarded with continued support for its preferred weapons system (e.g., the Aegis air defense system). A program manager who completes a project that experiences massive cost overruns and schedule delays is promoted (e.g.,

the MX missile system). Few penalties are levied against defense contractors who employ excessive optimism (C–5A transport plane), and few rewards are given to program managers who reduce costs, highlight potential risks, and improve performance if these achievements incur schedule delays (Skipper missile). According to the GAO, the failure to reward the very behavior that supports the focus of reform efforts is tied to a political culture that focuses on completing a military project rather than improving the process.

The statutory means are now available to alter this dynamic. The FASA requires the Defense Secretary to make personnel decisions (pay and promotions) on the basis of whether program managers achieve the projected cost, schedule, and performance goals for each phase of the acquisition cycle. In addition, it requires the Pentagon to report to Congress on whether it is within 90 percent of its cost, schedule, and performance goals for military hardware. Once again, however, the success of these mandates is contingent upon a certain amount of good faith. Critically, political forces (such as the reexamination of the military's role in the post-Cold War period coupled with massive cuts in the defense budget) that threaten to diminish the organizational role and stature of the military services could provoke the sort of recalcitrance that blocked the successful implementation of previous reforms. With less money available to develop military hardware and a reduced role, the services are likely to revert to the standard operating procedures of pursuing gold-plated weapons and embracing a concurrent management strategy to protect their diminishing turf. Moreover, any reforms that reinvent processes, procedures, and organizations in ways that alter incentives but initially threaten or eliminate jobs (such as downsizing, results-based budgeting or functional generalization) are likely to encounter "considerable bureaucratic resistance and organizational friction" (Thompson and Jones, 1994, p. 242). Similarly, any reform suggestions for increased privatization and competition, because they threaten the special relationship (monopsony) that the defense industry enjoys with DoD, are likely to be unpopular.

"...any reform suggestions for increased privatization and competition, because they threaten the special relationship (monopsony) that the defense industry enjoys with DoD, are likely to be unpopular."

A Pragmatic Perspective

A competing explanation for the failure to achieve radical procurement reform asserts that the direction of past and current recommendations is contrary to certain political, economic, international and technological imperatives. Although appealing in principle, efforts to improve the efficiency of the procurement process are impractical in a democratic political system committed to accountability, popular control, and equity.[3] In fact, many critics of current reform efforts are particularly offended by the condemnation of politics that is an implicit assumption of rationalism.[4] Pragmatists note further that the drive toward efficiency ignores unforseeable changes in the broader environment

that adversely affect military hardware development. In other words, forces not subject to control such as inflation, technological obsolescence, and international conflict can foil efforts to rationalize or reengineer weapons procurement (Mayer and Khademian, 1996; Chittick, 1988; Art, 1985; Gansler, 1989; Fox, 1988; Thompson, 1993; Haffa, 1988).

Where rationalist procurement reform pulls in the direction of attenuating the decision making process, the democratic imperative pulls in the direction of invigorating the process. In the American political system, the prevailing belief is that public decisions deserve to be made in a relatively open forum that allows for and credits input from multiple actors whose interests may be competing ones; to do otherwise is contrary to the conditions of a democracy. This is why congressional reforms mandating efficiency also strengthen the oversight component of the procurement process, even though the two forces pull in opposite directions. This also explains why Congress, despite being an impetus for the new public management, continues to be an obstacle to successful implementation of radical change because of its proclivity for legislative micromanagement (Thompson and Jones, 1994, p. 243).

"From a democratic perspective, aggressive oversight is critical, even if efficiency is sacrificed, because it sustains an active congressional (and by extension public) role in military matters."

From a democratic perspective, aggressive oversight is critical, even if efficiency is sacrificed, because it sustains an active congressional (and by extension public) role in military matters. Moreover, oversight has proven to be an important corrective measure in a number of cases where congressional action has amended the weapons acquisition process.[5] For example, legislative "interference" improved the performance capabilities of the M–1 tank and the M–16 rifle and brought out cases of malfeasance and questionable practices in the development of the Skipper (AGM–123A) missile, MX missile system, and F/A–18 (*Hornet*) fighter plane (Lindsay, 1991; Holland, 1997b).

Encouraged by an open political system, the public too has contributed productively to the military debate.[6] Daniel J. Kaufman credits media coverage of and public concern over the Defense Department's wasteful and fraudulent procurement practices (exemplified by the purchase of $600 hammers) as contributing to the reform efforts in the Pentagon (1987). The media are also lauded for their coverage of the M–16 rifle, Aegis air defense system, and the division air defense gun (DIVAD) that led to, respectively, a review of the rifle program by a special subcommittee in the House Armed Services Committee (now House National Security Committee), investigative hearings in Congress and a mandate for new operational tests, and Secretary of Defense Caspar Weinberger's decision to cancel the air defense gun.

The nuclear freeze movement is credited with influencing Reagan's decisions to soften his "rhetoric" and pursue serious arms control negotiations. In both the MX missile and B–1 bomber cases, public involvement (motivated by economic, social, cultural, and environmental considerations) raised fundamental national

security issues. Now that the end of the Cold War has invalidated the strategic missions of the MX and B–1, it is interesting to ask whether one condemns or applauds the fact that public involvement was instrumental in delaying their deployment.

Defenders of accountability also point out that circumventing the democratic process does not guarantee better quality military hardware. Both the F–117A fighter plane and B–2 strategic bomber were classified programs, designated "black" systems because of the national security implications of their development. The F–117A is considered to be an excellent plane, whereas the B–2 has encountered a number of mechanical problems. Even the F–117A program, however, experienced schedule delays, cost overruns, and performance failures that postponed the plane's readiness for several years (GAO, 1992), despite streamlined management and baselining.[7] Similarly, the requirement that off–the-shelf components be purchased to expedite development resulted in the ill-fated DIVAD anti-aircraft gun that Weinberger canceled after the Army sunk $1.5 billion into the program. Finally, the evidence that deregulation results in improved weapons procurement and military equipment is inconclusive (Thompson, 1992–93, p. 748).

A second claim by advocates of a pragmatic argument is that reform options that promote efficiency are naive given the vagaries (uncertainties) of the global environment, the American economic system, and technological development (Biery, 1992). While the complex web of rules, regulations, procedures, and organizations that characterize procurement in the U.S. have sought to bound these uncertainties (examples include the milestone review process and the Cost Analysis Improvement Group [CAIG]), they can at best be imperfect measures. National security problems for which military solutions (including weapon systems) are developed are extremely complex and ambiguous, the information necessary to make informed decisions is inherently uncertain and difficult to obtain, and the decisions themselves are responses to estimated "enemy" threats and military capabilities predicted for some undetermined future point in history. No amount of reinvention or reengineering can fully account for these uncertainties.

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In addition, because policy making does not occur in a laboratory situation, other uncontrollable forces influence military hardware decisions. Examples are the inflation that compromised the "fly before you buy" acquisition method, labor disputes that stalled the construction and timely completion of the *Trident* submarine, political opposition in Utah and Nevada that doomed the deployment of the MX missile system, and technological challenges that plagued the development of the B–1 strategic bomber. The concept of total-package procurement (TPP) introduced by Defense Secretary Robert McNamara in 1964 is often cited to illustrate how technical and cost uncertainties that arise during the early stages of development and the fluctuations in the national economy can doom even well-intended reform efforts (McNaugher, 1989; Stubbing,

1986). Ironically, the two major acquisition reforms that the C–5A disaster spawned—the milestone process and the "fly before you buy" concept—have both been subsequently compromised by political, economic, and strategic forces. For example, the "fly before you buy" mandate contributed to the protracted 20-year development of the M–1 tank.

Actualizing Reform

Despite conscientious recommendations to improve the process that is used in America to build major weapon systems, successful implementation has been imperfect. Both the incentive and pragmatic arguments offer convincing explanations for the failure to actualize radical reform in the Pentagon, and, thus, proffer a cautionary note to advocates of the new public management. Neither argument suggests totally abandoning the current body of rules, regulations, and procedures.

"Despite conscientious recommendations to improve the process that is used in America to build major weapon systems, successful implementation has been imperfect."

Taken together, the perspectives offer recommendations for accommodating efficiency, democracy, and the vagaries of the environment. The incentive argument promotes a viable system of reward and punishment to reinforce the direction of reform toward greater efficiency; that is, reward those who improve the process, not just the product, of procurement. Implicit in the pragmatic argument is the suggestion for a more flexible set of criteria for evaluating performance to compliment a strengthened reward system while preserving the current network of checks and balances.

These new criteria, however, must account for the fact that efficiency and performance excellence are sometimes incompatible; the vagaries of the political and economic system cause weapons to experience cost overruns and schedule delays that may actually improve their performance capabilities; and objectives other than efficiency, such as political accountability and equity, are commendable. The difficult thing is how to preserve the existing body of reforms and continue the drive for efficiency without abandoning the commitment to accountability, popular control and equity.

Kenneth Mayer and Anne Khademian suggest shifting the system of recompense from an exclusive emphasis on output performance to a consideration of input performance. In other words, key actors would be remunerated for respecting the legislative oversight and military milestone processes. Thus, rewards would be granted not only to those who cut program costs and field a timely weapons system that performs as expected (results-based budgeting, outputs evaluation), but also those who produce realistic cost estimates and conduct fair prototype competitions as mandated by federal law, even if efficiency is compromised in some cases. To make this complicated system of rewards and penalties work requires more flexible evaluation criteria that recognize that definitive standards of output performance are impossible to achieve in a democracy, and that input and output performance are often incompatible (Mayer and Khademian, 1996; Korb, 1994). Recent

legislation (Federal Acquisition Reform Act of 1996 [FARA]) continues the pattern, however, of rewarding program managers primarily for achieving results.

As a preliminary effort, the focus of a reformed system of recompense should be on the military services, particularly the relationship between funding and organizational stature. The military services must be discouraged from promoting unnecessary, untested, and unworkable hardware because their organizational lives depend upon shares of the budget. Continuous initiatives to streamline and centralize the management of military programs to improve efficiency and realism fail to address this problem and, therefore, merely sustain the status quo. An example is the FASA, which reduces paperwork and some oversight provisions such as strict testing and auditing requirements, but otherwise leaves the incentive system in tact.

The challenge to those seeking to alter the motivations behind procurement is to discourage parochialism, optimism, and protectionism while continuing to profit from the expertise of the military services (and the defense industry) in acquisition matters. Meeting this challenge requires reducing the control that the military services have over mission needs, enforcing oversight, and securing adequate and stable funding from Congress.

According to the GAO, the authority for determining mission needs must be removed from the military services and placed elsewhere, such as with the Joint Requirements Oversight Council (JROC), the Defense Resources Board (DRB), or the Office of the Secretary of Defense (OSD), (GAO, 1992, p. 63). Thompson and Jones contend that the combatant commands are already recognized as the "principal instruments" of defense policy, and should be allowed to operate as mission centers (1994, p. 223). In either case, power would remain with the services to build the weapons system. For the GAO, an energized Defense Acquisition Board (DAB) would work to avoid gold-plating and other problems. For Thompson and Jones, accountability would result from the requirement that the services compete in the sale of their equipment to the combatant commands (1994, pp. 223–227).

"The challenge to those seeking to alter the motivations behind procurement is to discourage parochialism, optimism, and protectionism while continuing to profit from the expertise of the military services (and the defense industry) in acquisition matters."

Only Congress, however, can ensure funding stability. How, though, do we guarantee that funding decisions are made by members of Congress in a reflective way that avoid the pitfalls of parochialism? In other words, how do we contain oversight within manageable boundaries that lessen the intrusive nature of legislative involvement? Thompson and Jones suggest that Congress provide budget authority to the combatant commands rather than to the military departments, a reform that would challenge the disproportionate power of the services (1994, pp. 229–230). Another recommendation is to embrace the process employed by Congress to make military base-closing decisions. Under this model, the DoD would submit its set of recommendations for needed weapon systems to an independent review

commission (staffed by experts) created by Congress. The commission then would give its recommendations to the President, who would forward his proposals to Congress. Congress would have the final authority, but with the requirement that it accept or reject the entire list.[8] The advantage of this process, which already has proven successful, is that it recognizes that some aspects of weapons procurement are too technical for deliberation in a public forum and retains the funding and oversight powers of Congress (and, thus, the public). It also neutralizes the disproportionate influence exerted by privileged actors, such as the defense industry and members holding key positions in Congress. The commission option would also encourage key players to view weapon systems as part of a coherent force structure rather than as discrete entities, in concert with the principle of mission budgeting.

"By cutting the thread that connects the defense industry to members of Congress, an important leg of the military subsystem would be neutralized."

A related, albeit ambiguous, suggestion is to implement more comprehensive campaign reform. If one concern is with the perceived parochial tendencies of some members of Congress, then the solution is to eliminate one potential incentive for hypocritical voting: political action committee and campaign contributions. Campaign reform would also help balance the disproportionate influence of the defense industry and labor unions in the military debate by eliminating an important source of their power. By cutting the thread that connects the defense industry to members of Congress, an important leg of the military subsystem would be neutralized. Nevertheless, campaign reform may not alter the cozy relationship between the military services and Congress that sometimes leads to weapon systems that have been canceled by the Secretary of Defense being restored by Congress (such as the Marine Corps' AV–8B Harrier and V–22 *Osprey* programs). The argument for campaign reform is ambiguous because empirical studies challenge the independent influence of political action committee and campaign contributions on legislative voting (Mayer, 1991). Nonetheless, any reform that liberates policy makers from indecorous forces has appeal.

To strengthen the oversight function of Congress, members need to be better informed. Those who condemn Congressional and public involvement as disruptive to the procurement process and distracting to defense experts cite the lack of knowledge and understanding of nonexperts. The logical solution to this argument would be to share more information, so legislative and public input is more substantive. This can be accomplished through statutory efforts such as the Freedom of Information Act of 1966 and greater use of public hearings by Congress and the Executive Branch (Holland, 1984). The Clinton administration's advocacy of the new public management, particularly information technology, could improve information transfer between the branches.

Advocates of oversight point to the important roles played by the legislative branch and the public in controversies such as the C–5A transport plane, M–16 rifle, B–1 bomber, DIVAD automated anti-aircraft gun, M–1 tank, and the MX

missile controversies. In the case of the M–1 tank, for example, preliminary errors of judgment made in the Pentagon were corrected in response to legislative concerns, resulting in the continuous improvement of the main battle tank. Increased oversight also could provide a basis for more aggressive enforcement of already existing criminal and civil codes to punish fraud, waste, and abuse in procurement matters, and hopefully, provide the requisite disincentives to disingenuous behavior. As a normative suggestion, Congress should refocus its energies from making weapons procurement decisions (which it is ill-equipped to do) to executing the sort of oversight that guards against fiscal, technical, and managerial malfeasance.

In order to retain a public role in military matters, Robert Dahl advocates an "extended adversarial process" in which the government's task, during the initial stages of weapons decisions, is to clarify the debate and reduce important issues to two opposing policies, one supported by the administration and the other defended by an opposition (1985). The public, then, is confronted with a narrowly construed choice, but a choice that defines the boundaries of permissible government action and lends legitimacy to policy decisions. For Dahl, the electoral process is the best forum for people to register an opinion on policy choices. However, opportunities exist for public response to governmental dilemmas even when there is not an election at stake, through public opinion polling techniques. In order for this process to work effectively, the government must make as much information available as possible.

A second obstacle to the actualization of reforms is the effect of the competing military, private and legislative interests served by weapons procurement. The direction of current reform is toward minimizing conflict by streamlining the process at the expense of a public and legislative role. The danger is that accountability is reduced to the point where the benefits of political debate are nullified. More important, in cases where conflict remains unresolved, as it has over such fundamental matters as what constitutes a threat to America's security and how to respond to these threats, forging a political consensus might be the only way to establish program legitimacy. Citizens are more likely to view the resources committed to weapons procurement as credible if they feel their opinions have been considered. When citizens rail against the biases in what is perceived to be a system controlled by military subsystems,[9] their discontent is with the absence of sufficient countervailing measures.

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A third obstacle to actualizing reforms are the vagaries of the political and economic systems and the military hardware process itself. Well-intended reforms to improve procurement must adjust to unexpected changes in technological development, the economy, and the global strategic environment. As noted earlier, current and past reform efforts have sought to bound these uncertainties in layers of processes and regulations. However, no amount of streamlined authority can compensate for the difficulties of making 5- to 15-year projections (the life cycle of an

average weapons system) about unknown features of the strategic environment. In that period of time, threats change, technology evolves, and political careers fluctuate. How, then, can we further reduce the adverse effects of uncertainty on weapons procurement?

One obvious solution, demonstrated in the academic literature, is to invest in less technologically ambitious weapons. In a recent study, the author found that technologically ambitious weapons are more likely to encounter performance problems, schedule delays, and cost overruns.[10] In contrast, in all of the cases examined in the study in which the technical requirements were modest ones, the systems performed as expected. Of particular prescriptive significance is the finding that moderate technological challenges are less likely to result in weapons with performance problems. The budget deficit in combination with improvements in Russian-American relations and accompanying arms agreements (Strategic Arms Reduction Talks [START], Intermedicate Nuclear Forces Treaty [INF], etc.) suggest a reconsideration of the current force structure away from overly ambitious (or highly risky) technology. Weapons posing moderate technological challenges (such as upgrades) are still technically sophisticated enough to sustain scientific progress.

"Of particular prescriptive significance is the finding that moderate technological challenges are less likely to result in weapons with performance problems."

According to Martin Binkin, procuring less technically demanding hardware can be accomplished by eliminating subsystems and requirements that are not essential to the mission (1986). Computer and cyber-technology can be directed more broadly to improving existing military hardware rather than to inventing new weapons. Because the technical challenges raised by retrofit development are less compelling than those posed by new scientific discoveries, both the uncertainties and costs that accompany advanced technology can be reduced. Advocates of moderate technology point to the success of the Air Force's F–16 fighter plane, which was developed under a flexible but moderate (not ambitious) set of performance requirements. It is important to keep these findings in mind, coming as they do at a time when the United States is said to be poised on the brink of a military-technical revolution.

What about the vagaries of the economic and strategic environments? To address economic uncertainties, Thomas McNaugher suggests a system of extended competition beyond the earliest stages of the procurement process, which means including the engineering and manufacturing (formerly full-scale development) and production phases (1989). Extended competition would require longer lead times, additional short-term funds, the elimination of sole-source contracts following prototype competitions, and the delay of contract awards until engineering and manufacturing, operational testing,, and early production have been completed. Congress already has legislated some of these changes in the Defense Procurement Improvement Act of 1985 and Title IX of The 1986 Defense Authorization Act .

Extended competition, in addition to increasing the opportunities for a specific

weapon's development to adjust to technical uncertainties before design and production decisions are crystallized, would also discourage those who employ optimism, deceit, and parochialism as tools to promote their preferences (the buy-in phenomenon). Without a guarantee that an research and development contract will lead to a production contract, or that a Milestone I decision will automatically lead to Milestone II and Milestone III approval, there would be more of an incentive for privileged actors to continue to be diligent and conscientious.

Advocates also contend that extended competition would encourage innovation and creativity. The Air-Launched Cruise Missile (ALCM) program is cited as an example of a program whose success can be partially attributed to extended competition throughout the pilot production stage. Competition also saved the Skipper air-to-surface missile despite an organized effort by Texas Instruments, then-Senate Armed Services Committee (SASC) Chair John Tower, and the Air Force to build the sleek, complex, and expensive Triple L. Here again, the suggestions for extended competition run contrary to the most recent congressional reforms that continue to focus on reducing competition to advance efficiency (The FARA and The Information Technology Management Reform Act of 1996 [ITMRA]).

Adjusting to strategic uncertainties poses the most formidable obstacle to the management of radical reform. The only option is to build enough flexibility into the procurement process that a weapon's development can adapt to changes in the global environment. Recommendations for functional generalization, decentralized decision making, and increased competition address this challenge in part. Moreover, in the absence of an imminent Soviet threat, weapons decisions can be comfortably made in a less hectic manner.

Conclusion

The purpose of the weapons acquisition process is to produce the systems that the United States can use to protect its vital national interests. A persistent mismatch between military needs and capabilities during the Cold War precipitated decades of reform efforts to improve both the procurement process and the outputs of that process, major weapon systems. The resulting recommendations have failed to be fully implemented, despite diligent efforts. The explanations for the failure to sufficiently realize procurement reform point to the prevailing incentive structure in which key players operate, the disruptive effects of uncontrollable forces in the global and domestic environments, and the incompatibility between the direction of reform (efficiency) and certain democratic imperatives (accountability).

Overcoming the obstacles to the effective implementation of existing reforms and accommodating the drive for efficiency and accountability require a more flexible system of reward and punishment; vigorous oversight; a redefined role for Congress, the public and the military services; a commitment to invest in less risky technology; and an extension of the procurement process. Otherwise, current efforts to reengi-neer the Pentagon to improve America's military capabilities will continue to be frustrated.

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ENDNOTES

1. The Office of the Secretary of Defense (OSD), responding to the General Accounting Office (GAO) indictment, asserts that acquisition problems can be attributed "to a lack of discipline and to the pressures of the Cold War" (GAO, 1995, p. 13). With the Cold War over, the Pentagon need only execute changes in discipline.

2. Michael Brown, in a study of manned strategic bombers, found that concurrency has the most viability in cases where the technology demanded by the weapon is modest or moderate in nature. The appropriate strategy in cases of sophisticated technology is a sequential one (1992).

3. The commitment to the principle of equity sustains the concessions to small businesses and women- and minority-owned firms in contracting decisions, despite the additional costs that are sometimes incurred.

4. Typical of the rational argument is Thomas McNaugher, who asserts that "reform must seek to remove political incentives from an elaborate technical process whose proper workings they can only disrupt" (1989, p. 182). What this attitude ignores is the creative impetus that politics can provide to procurement innovation. In his book on weapons innovation in the Soviet Union and United States, Matthew Evangelista credits American ingenuity in military matters largely to the open, porous and informal structure of the national security system (1988). In this sense, then, politics is a counterweight to narrowness and bias in decision making, which can result when the scope of participation is so narrowly construed that weapons development reflects the opinions or views of a small group of same-thinking experts.

5. For institutional and political reasons, Congress seldom places itself in an adversarial position on weapons procurement matters. More often, members of Congress seem content to tinker on the margins of military hardware matters, with some important exceptions. However, it is the exceptions that have fueled efforts to insulate the Pentagon from these "disturbing" outside forces.

6. With the exception of the mass media and special interest groups, the role of the public has been a marginal one in military hardware decisions. For the most part, the public lacks the interest and means to play an important role in weapons decisions. Notable exceptions are the MX missile, B–1 bomber, Trident submarine, and M–16 rifle programs. Moreover, since a public role is not a formal part of the defense policy-making process, its effectiveness depends upon the willingness of decision makers to translate public preference into government action. Even special interest groups, which exert the most immediate, direct, and significant impact on policy

making in the United States, lack formal policy authority and must rely upon intermediaries.

7. According to the GAO (1992), baselining is the practice "whereby a program office 'contracts' with top management to develop a system that meets basic performance, cost, and schedule requirements in exchange for stable funding and minimal interference."

8. The Center for Strategic and International Studies has suggested an additional mechanism, a General Advisory Board on Defense Acquisition, which would monitor and report annually on whether progress is being made in implementing existing reforms.

9. A military subsystem describes a reciprocal policy making dynamic involving the military services in the Pentagon, defense contractors, and the Congressional Armed Services Committees and Appropriations Subcommittees, all guided by personal and organizational concerns. (See Holland, 1997a.)

10. The data focus on the association between technologically ambitious weapons and flawed ones. Each of the nineteen cases in the study was classified by the amount of challenge demanded by its technical requirements. Ambitious programs were those that challenged scientists and technicians to discover new principles or applications. Moderate programs generally involved the less demanding challenge of combining familiar principles or applications in new and complex ways. Demands were modest when scientists were required merely to apply and build upon known principles. Technological sophistication was then correlated with the performance status of each system. Performance status refers to whether a weapon met its performance goals at its initial operational capacity (IOC) date (Holland, 1997b).

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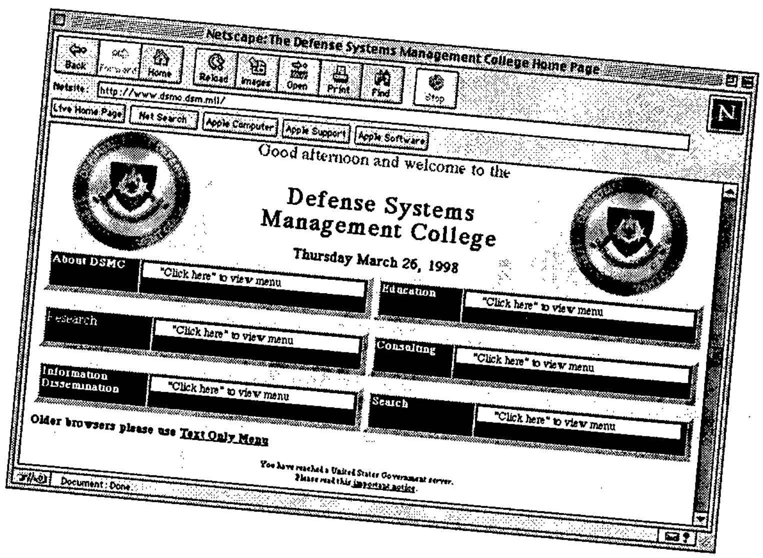

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- Division of College Administration and Services (DCAS)
- Divisions/Faculty Departments
- DSMC Alumni
- DSMC Course List
- The Executive Program Manager's Course (EPMC)
- Access to the EPMC Intranet
- Learning Resource Center
- Program Management
- Regional Centers
- Registrar

Consulting

- The Cost Analysis Strategy Assessment (CASA) model
- Expertise List
- Management Deliberation Center (MDC)/Group Services
- Consulting Services

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